NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA EARTH SCIENCE RESEARCH FOR INTERNATIONAL AIR QUALITY POLICY

Part 2: Evaluation and Recommendations on the Potential for Application of NASA Earth Science Research to International Air Quality Treaties/Policies/Protocols

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Subaward Agreement #CG0416

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Washington, DC 20024

February 1, 2005

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EXECUTIVE SUMMARY

This report examines selected international air quality policy instruments with the greatest potential for application of NASA Earth science resources and makes technical and policy recommendations for NASA to increase its involvement. The information derived from NASA Earth science sensors and models is potentially useful for all phases of the process of developing and implementing environmental agreements because they provide unique, objective environmental data with global, homogeneous, and repetitive coverage. NASA resources could enable policymakers to better visualize, monitor, and quantify the geospatial extent, intensity, and movement of air pollution, particularly in remote regions and across international boundaries, and significantly enhance the current network of ground-based air pollutant monitors and meteorological-based models.

The first section provides the global context of policy applications for Earth observation data. For the following two policy instruments with the highest potential for application of NASA Earth science resources, the structure and organization, key protocols or annexes, technical issues, and recommendations for further NASA involvement are discussed:

- *Convention on Long-Range Transboundary Air Pollution (LRTAP).* LRTAP represents the foundation of global policy for the study and control of transboundary air pollution. There may be opportunities for NASA to support existing and future protocols on such issues as ozone and fine particulate matter, as well as support a U.S.-led work group studying hemispheric air pollution transboundary issues.

- *U.S.-Canada Bilateral Air Quality Executive Agreement.* Transboundary issues with Canada have immediate importance and relevance to U.S. policy. There may be opportunity for NASA involvement in both assessing the effectiveness of existing annexes and developing a new particulate matter annex.

Two additional policy instruments with less potential for near-term application of NASA Earth science resources, and less of a direct focus on air quality, are also addressed briefly: the *United Nations Convention to Combat Desertification* and the *International Convention for the Prevention of Pollution from Ships*. NASA has an existing program on land use that could coordinate with resources that monitor transport of dust to increase understanding of the human and ecological health issues of air pollution from desertification. Concern over air pollution from ships is increasing and new research efforts could be enhanced by remote sensing of major shipping lanes.

The concluding sections outline a broader framework for NASA involvement in international policy, and provide near- and long-term recommendations for NASA to transition

from concept to action. The near-term actions emphasize coordination within NASA and with other U.S. Federal agencies and parties engaged in international air quality policy. The long-term actions focus on self-examination of NASA's overall approach to involvement in international policy, highlighting structural problems to maintaining involvement in long-term policy development, negotiations, and implementation.

1.0 INTRODUCTION

1.1 Purpose

In recent decades, environmental treaties have grown in number, scope, and complexity. An overview of international air quality agreements, treaties, conventions, protocols, and guidelines (collectively termed policy instruments) with U.S. involvement was presented in the Part 1 report[1] of this project, along with a brief assessment of the potential application of NASA Earth science research to these policy instruments. This Part 2 report builds upon Part 1 by examining selected policy instruments with the greatest potential for application of NASA Earth science research and proposing specific actions for NASA to increase its involvement. The purpose of this report is to provide the staff and management of the NASA Applied Sciences Program an introduction to international policy, with a particular focus on international air quality policy instruments and how NASA could become more involved in supporting the development and implementation of such instruments.

Since its creation, NASA has been studying the Earth and its changing environment with a focus on scientific research into natural processes and their relationship to human activities. NASA scientists have applied their research and resources to international environmental policy and in some cases they have been instrumental in understanding the scientific issues related to the policies' development (e.g., stratospheric ozone hole and the Montreal Protocol).[2] NASA has shown increasing interest in pursing activities on policy application of its Earth science research, partially as a result of a 2002 mandated program review[3] that encouraged NASA to increase the usefulness and availability of its Earth observation datasets. While this program review concluded that satellite sensor data collections had increased over the previous 10 years, the review noted that the data are not all easily accessible and the lack of documentation and description of products inhibits their use by "experts in the fields to which the data are being applied."[4] The review also stated that "Investments in scientific analysis and in packaging data in formats useful to other potential users, including educators, those in industry, state and local government officials, and policymakers, will be needed in order to exploit the full potential of existing data sets."[5] Given the extensive NASA Earth science research on the atmosphere and air quality, its nascent work in developing products for use by the U.S. air quality community,[6] and the increasing number of international policy instruments focused on these topics, there is great potential for application of NASA Earth science research to selected policy instruments.

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[1] National Aeronautics and Space Administration Earth Science Research for International Air Quality Policy; Part 1: Overview of International Air Quality Treaties/Policies/Protocols and a Brief Assessment of the Potential for Application of NASA Earth Science Research; Jill Engel-Cox & Erica Zell, Battelle; August 27, 2004.
[2] Bowman, K.P. and A.J. Krueger, 1985. A global climatology of total ozone from the Nimbus-7 Total Ozone Mapping Spectrometer. Journal of Geophysical Research 90, 7967-7976.
[3] National Research Council, Space Studies Board, Board on Earth Sciences and Resources, Assessment of the Usefulness and Availability of NASA's Earth and Space Science Mission Data, 2002.
[4] Ibid.
[5] Ibid.
[6] Engel-Cox, J.A., R. M. Hoff, and A.D.J. Haymet, Recommendations on the Use of Satellite Remote-Sensing Data for Urban Air Quality, Journal of the Air and Waste Management Association, ISSN 1047-3289, November 2004.

The information derived from NASA resources is potentially useful for all phases of the process of developing and implementing environmental agreements because NASA sensors and models provide unique, objective data that have the additional advantage of yielding global, homogeneous, and repetitive coverage. NASA Earth science research can have a role in identifying global air quality problems, monitoring and assessing those problems, and developing international agreements (including direct participation by NASA technical experts at the workgroup level). NASA Earth observation data, and the associated models and analysis systems, can also provide accountability, determining the overall effectiveness of an international environmental agreement in terms of measurable physical results.

1.2 Scope

NASA is interested in expanding the use of its unique scientific capabilities to support international policy, with an initial focus on air quality and atmospheric science. This Part 2 report examines selected policy instruments with the greatest potential for application of NASA Earth science research, and makes technical and policy recommendations for NASA to increase its involvement.

The report begins by describing the global context of policy applications for Earth observation data. The report discusses existing global monitoring efforts by organizations such as Integrated Global Observing Strategy (IGOS), Committee on Earth Observation Satellites (CEOS), and Group on Earth Observations (GEO) and addresses the linkages that these groups have made to the application of international policy instruments. The report also briefly benchmarks a progression of European Space Agency (ESA) programs focused on policy applications of Earth observation data.

The main section of the report examines the following policy instruments based on the conclusions of the Part 1 report, NASA recommendations[7], and the potential for application of NASA resources:

- Convention on Long-Range Transboundary Air Pollution (LRTAP) (see Section 3.1). This Convention was selected because it represents the foundation of global policy for the study and control of transboundary air pollution, and because of opportunities for NASA to support existing and future protocols on such issues as fine particulate matter.

- U.S.-Canada Bilateral Air Quality Executive Agreement (see Section 3.2). This Convention was selected because transboundary issues with Canada have immediate importance and relevance to U.S. policy and because there may be opportunity for NASA involvement in both assessing the effectiveness of existing annexes and developing a new particulate matter annex.

The discussion of each of these policy instruments begins with the structure and organization of the convention and implementing body, and details of the key protocols or annexes. The technical issues are discussed for each policy instrument, followed by recommendations for further NASA involvement. The report also discusses the air quality

[7] Meeting with Lawrence Friedl, NASA, Earth Science Applications, October 6, 2004.

aspects of two policy issues of secondary interest: desertification (Section 3.3) and marine ship air pollution (Section 3.4). The discussion of each of these issues focuses on key policy instruments, current U.S. involvement, and ongoing research, concluding with recommendations for potential NASA involvement.

The report concludes by outlining a broader framework for NASA involvement in international policy (Section 4.0) and providing near- and long-term recommendations for NASA to transition from concept to action (Section 5.0).

Appendix A explains the background and terminology of international environmental law, including the role of the United Nations (UN), legal terminology, international treaty management and monitoring, and a glossary of key terminology. Appendix B contains key information tables for each international air quality agreement, treaty, convention, protocol, and guideline, adopted from the Part 1 report.

2.0 GLOBAL CONTEXT

In addition to the 2002 program review to which NASA is responding by exploring the potential for policy applications of its Earth observation data (see Section 1.1), there is a broader global effort underway for an integrated global observation system, and application of this system to international environmental policy instruments. The need for an integrated global observation system has been defined and validated by numerous summits on the environment and international development. The action plans resulting from these summits have also included references to the value of such a system in the international policy instrument arena.

While this report focuses on options for NASA to apply its own Earth observation data to international policy instruments, it is valuable to examine efforts underway for an integrated global observation system because these efforts are addressing many of the issues that NASA will need to consider to increase its involvement in international policy instruments. In addition, NASA is already involved with CEOS, IGOS, and GEO. NASA should capitalize on this involvement as it pursues recommendations of this report. Therefore, this section discusses existing global monitoring efforts by IGOS, CEOS, and GEO, and addresses the linkages that these groups have made to international policy instruments applications. In addition, this section briefly benchmarks a progression of European Space Agency (ESA) programs focused on policy applications of Earth observation data.

The summits on the environment and international development that have called for an integrated global observation system and application to decisionmaking and international policy instruments are as follows:

- From the UN Conference on the Environment and Development in 1992, Agenda 21 states "… Relevant international organizations should develop practical recommendations for coordinated, harmonized collection and assessment of data at the national and international levels" (Section 40.9).[8]

- From the Ninth Session of the Commission on Sustainable Development (created by Agenda 21, New York, April 2001), Decision 9/4 (Information for Decision-making and Participation) states "The Commission: … (d) Urges strengthened cooperation and coordination among global observing systems and research programmes for integrated global observations, taking into account the need for sharing, among all countries, of valuable data such as ground based observation data and satellite remote sensing data."[9] In addition, Decision 9/2 (Atmosphere) states "…The Commission emphasizes the importance of: … (d) Encouraging relevant international organizations, especially the United Nations specialized agencies, to jointly plan and implement a strategy for integrated global observations to monitor the Earth's atmosphere."

[8] UN Department of Economic and Social Affairs, Division for Sustainable Development, Agenda 21, http://www.un.org/esa/sustdev/documents/agenda21/index.htm.
[9] International Institute for Sustainable Development (IISD), Summary of the Ninth Session of the Commission on Sustainable Development: 16-28 April 2001, April 2001, 5(183), http://www.iisd.ca/vol05/enb05183e.html.

- From the World Summit on Sustainable Development (WSSD, Johannesburg, 2002), the Plan of Implementation that was adopted by Heads of State includes 12 references to global/satellite/earth observation/remote sensing.[10] With respect to implementation of the UN Framework Convention on Climate Change (UNFCCC), the Plan of Implementation states that actions are required to "promote the systematic observation of the Earth's atmosphere, land and oceans by improving monitoring stations, increasing the use of satellites and appropriate integration of these observations to produce high-quality data that could be disseminated for the use of all countries, in particular developing countries" (Section IV; 38[g]).

2.1 Global Monitoring Efforts

One of the major players in global monitoring efforts is IGOS, a partnership that brings together 14 international bodies concerned with the observational component of global environmental issues to produce comprehensive global, regional, and national data and information to satisfy the environmental information needs of policymakers, and to support scientific and operational environmental programs. The principal objectives of IGOS are to address how well user requirements are being met by existing technology and potential improvements through better integration and optimization of remote sensing (especially space-based) and in-situ systems. IGOS guides entities responsible for defining and implementing individual observing systems.[11] IGOS and one of its key member organizations, Committee on Earth Observation Satellites (CEOS), have been actively engaged in highlighting how global observations can support international environmental policy instruments and, more broadly, sustainable development. This section provides a brief background on IGOS, CEOS, and GEO, and their activities related to international environmental policy instruments.

2.1.1 Integrated Global Observing Strategy (IGOS)

NASA is currently involved in a number of the international bodies that are IGOS partners, but is not a direct IGOS partner. Similarly, the ESA and National Space Development Agency of Japan are among the many other members of the IGOS partners.[12] The IGOS partners have been working in arenas such as the Conference of the Parties of the UNFCCC, the Intergovernmental Panel on Climate Change (IPCC), and the UN Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE), to ensure that observing systems are considered when defining common strategic goals and concerted actions.

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[10] World Summit on Sustainable Development Plan of Implementation, http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIToc.htm.

[11] IGOS Overview, http://ioc.unesco.org/igospartners/over.htm.

[12] The complete list of IGOS partners includes: Committee on Earth Observation Satellites (CEOS), Food and Agriculture Organization of the United Nations (FAO), Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), Global Observing System/ Global Atmosphere Watch of WMO (GOS/GAW), Global Terrestrial Observing System (GTOS), International Council for Science (ICSU), International Geosphere-Biosphere Programme (IGBP), International Group of Funding Agencies for Global Change Research (IGFA), Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Climate Research Programme (WCRP), and World Meteorological Organization (WMO).

The approach of IGOS is to adopt priority themes for which study teams are formed to assess and report on environmental observation needs (including observational systems, data handling, processing and analysis infrastructure). The report is followed by the establishment of an implementation team with the responsibility and capacity required for the long-term implementation of the necessary operational networks. Through its theme-focused work, the IGOS Partnership has initiated discussions with representatives of 10 major multilateral environmental agreement regimes to review possible ways in which IGOS might be able to help support the data and information needs of these agreements.[13]

The IGOS theme related to the atmosphere is called the Integrated Global Atmospheric Chemistry Observation (IGACO) System, which recently released a report with technical recommendations on a global atmospheric monitoring system.[14] This report states: "Most [international environmental] agreements call for the monitoring, reporting or assessment of data on environmental parameters… It is to support these various agreements that IGACO… is principally conceived." The 11th IGOS Partners meeting was held on November 18, 2004 in Beijing, China, with a focus on development of the IGOS Partners' position regarding the Group on Earth Observations (GEO, Section 2.1.3) and its governance.

2.1.2 Committee on Earth Observation Satellites (CEOS)

CEOS is "an international coordinating mechanism charged with coordinating international civil space borne missions designed to observe and study planet Earth."[15] CEOS membership encompasses the world's government agencies responsible for civil Earth observation satellite programs, including NASA, along with agencies that receive and process data acquired from space.

At the WSSD, CEOS made a number of presentations emphasizing the role of space observations. Two "Type-II" (voluntary, private-public) partnerships were launched to implement WSSD recommendations relevant to global earth observation: one by IGOS for the use of space and ground measurements for sustainable development and one by CEOS to encourage partnerships on education and training.[16] The Type-II partnerships highlight the benefits of CEOS and IGOS for sustainable development to institutions such as the World Bank, regional development banks, the Global Environmental Fund (GEF), and the UN Development Program, all of which have a long-term mandate to support development activities.

As a follow up to the WSSD, CEOS continues its efforts to connect with key international bodies and conventions. CEOS participated in the Earth Observation Summit held

[13] Integrated Global Observing Strategy Partners, Coordination with Convention Secretariats, UN Environment Program, Fifth Session (Item 8.2), Geneva, 7 June 2000, IGOS-P5/Doc. 12 (06.VI.2000), http://earthwatch.unep.net/about/docs/igosp512.htm, accessed 7/21/04.
[14] Integrated Global Atmospheric Chemistry Observations (IGACO) Theme Report, September 2004, http://www.luna.co.uk/~pborrell/p%26pmb/IGACO/IGACO-report.htm, also provided in hard copy by Ernest Hilsenrath, NASA Goddard Space Flight Center, November 9, 2004.
[15] Committee on Earth Observation Satellites, http://www.ceos.org/pages/overview.html.
[16] World Summit on Sustainable Development, Type 2 Partnership Initiatives, http://www.johannesburgsummit.org/html/documents/summit_docs/2908_partnershipsummary.pdf.

in Washington, D.C., on July 31, 2003, following which the ad hoc Group on Earth Observations[17] (GEO) was established.

2.1.3 Group on Earth Observations (GEO)

As a result of the Earth Observation Summit in July 2003, GEO was established as an ad hoc group to develop a 10-year implementation plan for building a comprehensive, coordinated, and sustained Global Earth Observation System of Systems (GEOSS). GEO is an intergovernmental group co-chaired by the European Union, Japan, South Africa, and the United States. In addition, organizations such as CEOS participate in GEO as non-voting observing parties. GEO has created a Secretariat and has five subgroups, including a User Requirements subgroup that is tasked with identifying existing inventories of major user requirements and their present status and establishing the means to engage users in a continuing dialogue on their current and evolving requirements.[18] In the Spring of 2005, GEO will transition to become a formal body and the Secretariat will be housed with the World Meteorological Organization in Geneva. The U.S. delegation to GEO is led by the National Oceanic and Atmospheric Administration (NOAA).

The Interagency Working Group on Earth Observations (IWGEO) was formed to develop a 10-year plan for implementing the United States' components of GEOSS. The IWGEO is co-chaired by Ghassem Asrar of NASA and is comprised of representatives from 15 U.S. government agencies, including NOAA and the Office of Science and Technology Policy. The IWGEO was structured to mirror GEO; along with an executive secretariat and a planning and integration team, the IWGEO contains teams on architecture, data utilization, user requirements and outreach, capacity building, and international cooperation.[19] NASA will likely play a supporting role to NOAA on GEO, providing access to NASA data and other assistance.[20]

2.2 Benchmarking of Current Policy Applications

There are several major programs in Europe that include a focus on the application of remote sensing to specific treaty provisions. The overarching program is the Global Monitoring for Environment and Security (GMES) initiative, a joint initiative of European Commission (EC) and the European Space Agency (ESA), adopted in 2001. Multiple programs have been conducted under GMES; this section discusses the background, results, and current activities of relevant programs.

[17] Group on Earth Observations, http://earthobservations.org/.
[18] Committee on Earth Observation Satellites 2003 Annual Report, http://www.ceos.org/pdfs/CEOS_Annual_Report_2003.pdf.
[19] United States Interagency Working Group on Earth Observations, http://iwgeo.ssc.nasa.gov/.
[20] Meeting with Peter Meister, NASA, Earth Sciences Enterprise, January 26, 2005.

2.2.1 Treaty Enforcement Support using Earth Observation (TESEO)

ESA established TESEO in 2001 in support of GMES, and initiated pilot projects on the UNFCC Kyoto Protocol and the UN Framework to Combat Desertification (UNCDD), as well as two agreements on wetlands and oil spills.[21] The goals to be achieved by each pilot project were:

- "Identification of the main national and international bodies involved in the implementation of the treaty and exhaustive collection of their needs in terms of information products, potentially based on EO [Earth observations];
- Identification of the potential and limits of existing and future (planned or not) EO technology to contribute to match end users requirements;
- Definition of a set of novel EO-based products and services aimed at supporting the implementation of the treaty;
- Development of the technical capabilities to provide novel EO-based products and services to end users within the context of the considered international treaty;
- Development of at least two Prototype Products aimed at demonstrating the capabilities of existing and future EO technology to support end users in the implementation of the main actions and policies foreseen in the considered treaty;
- Providing general recommendations for future European EO missions and programmes."[22]

Each TESEO pilot project had a budget of 250,000 euros and was conducted by a contractor between August 2001 and December 2002. The end users of interest for the pilot projects were both the main bodies established within the context of the treaties and international groups such as non-governmental organizations (NGOs) and other entities involved in the implementation of the treaties (e.g., European, national, regional and local authorities). One example TESEO pilot project on desertification[23] is highlighted in the text box on the following page. A TESEO User Questionnaire was developed to obtain specifics on the needs of potential end users.[24] In addition to the online sources cited with information on TESEO, the ESA has also produced a CD containing a summary of the program and its results.[25]

[21] European Space Agency, Treaty Enforcement Services Using Earth Observation, http://styx.esrin.esa.it:5000/teseo/about.htm.
[22] Ibid.
[23] Holecez, F., Heimo, C., Moreno, J., Goussard, J., Fernandez, D., Rubio, J., Erxue, C., Magasar, E., Lo, M., Chemini, A., Stessel, S., Rosenqvist, A. Desertification – A Land Degradation Support Service, http://www.sarmap.ch/IGARSS03_TESEO.pdf.
[24] TESEO User Questionnaire, http://styx.esrin.esa.it:5000/teseo/us_d.doc.
[25] ESA, Environmental Conventions and Observation from Space, available from eohelp@esa.int; see also Barico, *et al.*, Desertification – A Land Degradation Support Service, http://www.sarmap.ch/IGARSS03_TESEO.pdf.

Example: TESEO Pilot Project on Desertification

The TESEO pilot project on desertification (and the UNCDD) was performed by a Swiss/French/Spanish/Chinese team, led by the Swiss company Sarmap. The UNCCD focuses on the development of national and regional action programs by national governments in cooperation with international organizations and funding agencies to combat desertification and mitigate the effects of drought, in particular in the African continent. The pilot project team studied the development of a land degradation support service for the generation of maps to be used by decisionmakers for identification of specific areas of desertification vulnerability and assessment of large-scale trends. The service is based on the idea that land degradation is influenced by both climatic and human-induced factors, and therefore, that the understanding and mapping of desertification requires a methodology based on Earth Observations (EO) integrated with data such as socioeconomic data. The service was developed in close cooperation with end users, based on both scaleable indexes (from EO data) and on indicators of human and animal pressure on natural resources. The EO products are multi-sensor, multi-resolution, and multi-temporal, including generic EO products (such as a scaleable vegetation index) and specific EO products (such as Digital Elevation Model, leaf water content, and salinity).

The primary barrier to utilization of EO technology identified by the team is the "wrong and wide spread opinion" that EO is a high-cost, high-tech tool restricted to use by specialists. The team concluded that the use of EO data will increase the efficiency and effectiveness of desertification monitoring and assessment methods and early warning systems. The team emphasized the need for synergy between low and high spatial resolution data, as well as between polarimetric synthetic aperture radar and hyper-spectral systems, and the need for multi-temporal data with adequate repetition frequency, long-term continuity and sensor consistency, and image geometry consistency. The team noted that the available data archives are generally "fragmentary and make it difficult to implement an operational service at a regional scale."

2.2.2 ESA Data User Element (DUE)

As a follow-up to the TESEO initiative, ESA's Data User Element[26] (DUE, a funding mechanism of ESA for information services development projects) is carrying out more than 50 demonstration projects in collaboration with different conventions.[27] The mission of the DUE is "to encourage the establishment of a long-term relationship between user communities and Earth Observation." DUE projects emphasize the early demonstration and qualification of information services, and are each funded with 1 million euros. One such project is DESERTWATCH[28] which focuses on the development of an EO-based information system to support national and regional government in reporting to the UNCCD and monitoring desertification trends over time.

2.2.3 TESEO Users Brainstorming Events (TUBES)

The ESA conducted three follow-up workshops called TESEO Users Brainstorming Events (TUBES) which gathered the convention Secretariats and the users of the TESEO projects in order to guide and consolidate the work of the pilot projects. Activities included a demonstration of prototype products and preparation of recommendations to ESA. Participants

[26] ESA Data User Element, http://dup.esrin.esa.it/projects.asp.
[27] Email from Diego Fernandez Prieto, European Space Agency, EO Science & Applications Department, Diego.Fernandez@esa.int, October 29, 2004.
[28] European Space Agency, Data User Element, Desertwatch, http://dup.esrin.esa.it/projects/summaryp65.asp.

in the third TUBES included governments and NGOs from around the world along with UN and university representatives.[29] ESA is planning to organize another TUBES in 2005 involving industry, research groups, and, especially, the user community from the TESEO pilot projects.[30]

2.2.4 Earthwatch GMES Services Element

In parallel to TESEO, the ESA created Earthwatch GMES Services Element[31] (abbreviated GSE) in 2001 as a five-year program to deliver policy-relevant services to end users, primarily (but not exclusively) from Earth observation sources. GSE enables end users to provide key input in the transition from current Earth observation satellites to future European systems that will provide information on global environment and security. In this context, end users include national environment ministries, the European Environmental Agency, and companies hired by these government units, to fulfill requirements (e.g., reporting) under multi-lateral environmental agreements.[32] End users also include commercial research laboratories, and other commercial groups interested in atmospheric data combined with meteorological data for products such as sunscreens.[33]

The primary objectives of GSE are:

- "In the short term, to ensure the maximum use is made of Earth observation services in support of European policies on environment and security.
- In the longer term, to establish the case for future Earth observation operational systems that can deliver policy-relevant information for the benefit of Europe's citizens."[34]

ESA is primarily using its own data for GSE, but will also use NASA's Ozone Monitoring Instrument (OMI) data because of its increased coverage, if it is available. ESA is also planning new Sentinel satellites.[35] GSE is organized to identify and manage issues that are of common relevance for different GSE services in a coordinated manner. GSE has a total budget of approximately 83 million euros. GSE is being implemented in two stages: Services

[29] Centre de Suivi Ecologique (Senegal), Environmental and Food Agency (Iceland), Estación Biologica de Do ñana (Spain), European Comission, European Forest Institute (Finland), FAO, Federal Environmental Agency (Austria), Global Mechanism of the UNCCD, International Gorillas Conservation Programme (Rwanda), Italian Ministry for the Environment and the Territory (Italy), Ministerio del Medio Ambiente (Spain), National Agency for the Energy and the Environment (Italy) , Observatoire du Sahara et du Sahel (Tunisia) , Ramsar Convention Bureau, SCBD (Canada) , UNEP-GRID, UNEP-WCMC, University of Tuscia (Italy), UNESCO, World Resources and World Wildlife Fund.
[30] Email from Diego Fernandez Prieto, European Space Agency, EO Science & Applications Department, Diego.Fernandez@esa.int, October 29, 2004.
[31] European Space Agency, Global Monitoring for Environment and Security, http://earth.esa.int/gmes/.
[32] Conversation with Brian Tittley, European Space Agency, ESA/ESRIN, Via Galileo Galilei, 00044 Frascati (RM), Italy, Tel. 06-941 80 574, Brian.Tittley@esa.int, November 3, 2004.
[33] Conversation with Claus Zehner, European Space Agency, ESA/ESRIN, Via Galileo Galilei, 00044 Frascati (RM), Italy, Tel. 06-941 80 544, Claus.Zehner@esa.int, November 8, 2004.
[34] ESA Earthwatch Programme GMES Services Element, Public Information Note, EW-GSE-EOAD-INFO-02-0001, Issue 1.0, July 2002, http://earth.esa.int/gmes/ESA_GSE_public_info._note_1.pdf.
[35] Ibid.

Consolidation (approximately 2002-2003), and Full Operation (approximately 2004-2006).[36] In the first phase, consortia were formed around each of 58 service areas ranging from urban mapping, coastal zone management, and water pollution, to atmospheric, crop, forest, and ice monitoring.[37] These consortia brought together a wide range of partners including government agencies, remote-sensing and GIS private companies, and universities (mostly European but also including Canadian partners); the United States is not involved in GSE. Each consortium prepared a proposal to ESA that included a demonstration of growth of their service over 10 years, as a means of documenting sustainability. At the conclusion of this stage, end users were surveyed to gather feedback on the services. One of the best sources of publicly available information on the first stage is the findings report[38] of a recent GSE meeting [Third GSE Co-location Meeting held at ESA European Space Research Institute (ESRIN), Frascati, Italy, May 3-6, 2004]. The attendees included end users, geo-information service providers, system integrators, research and development organizations, and expert consultants in environmental policy, international law, security issues, and economics.

The only GSE service directly related to air quality is PROtocol MOniToring for the GMES Service Element[39] (abbreviated PROMOTE), which is led by the Dutch company KNMI. PROMOTE's mission is "to construct and deliver a sustainable and reliable operational service to support informed decisions on the atmospheric policy issues of stratospheric ozone depletion, surface ultra-violet (UV) exposure, air quality and climate change." PROMOTE is based on integration of surface data, balloon/aircraft data, and space data into models. The international environmental policy instruments that are driving PROMOTE are the Kyoto Protocol, Montreal Protocol, UN Conference on Environment and Development Agenda 21,[40] several EU directives, and LRTAP.

PROMOTE runs from April 2004 to November 2005 (PROMOTE is running about a year behind the rest of GSE, in part because of the unusually large consortium). The areas of service are currently in different stages of development and implementation, as follows:

- Basic services on stratospheric ozone and surface UV are fully operational and sustainable. ESA has time series data for these areas dating back to 1985. ESA is currently collecting feedback from end users of the services being provided, and also focusing on attracting new users who are not currently using Earth observation services.

- Services on air quality are in the demonstration phase, focused on showing that satellites may be useful data sources in combination with a country's ground-based air quality monitoring network to support a country's monitoring and reporting requirements. To

[36] ESA Data User Programme Market Development & GMES Services Element (GSE), Mark Doherty, Exploitation Development Division, Earth Observation Programmes Directorate, European Space Agency, Presentation at GMES forum Brussels, July 16, 2002, http://earth.esa.int/gmes/GSE_at_GMES_forum_1.pdf.
[37] GSE List of Services, http://earth.esa.int/gmes/Services.html.
[38] Findings From the 3rd GSE Colocation Meeting, http://earth.esa.int/gmes/coloc3/findings_summary_report.pdf.
[39] http://www.knmi.nl/samenw/promote/.
[40] Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the UN, governments, and major groups in every area of human impact on the environment. Agenda 21 was adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janerio, Brazil in June 1992.

date, end user environmental agencies have indicated a need for higher spatial resolution and more frequent satellite passes.

- Services for climate change are in the development phase focused on input from the scientific community on end user needs.

A significant part of the research and development work planned for PROMOTE is funded by the European Commission Research and Technology Development program. This work includes the projects CREATE (Construction, Use and delivery of a European Aerosol Database), DAEDALUS (Delivery of AErosol proDucts for Assimilation and environmentaL USe), and GATO (Global Atmospheric Observations), among others.

PROMOTE and GSE have generally been viewed as successful by ESA and are linked directly to planning of future ESA satellite missions. ESA is planning to separate future satellite missions into two lines: scientific missions and operational missions. The operational missions may be focused around a specific theme, such as air quality. In some cases, ESA is paying end users to be involved with ESA in developing requirements for future missions. ESA emphasizes the importance of not over-selling satellites to end users, but rather being clear about the benefits and limitations of satellite data.

An event of interest is the Earth & Space Week[41] exhibition (Brussels, February 12-20, 2005) including ten GMES initial service demonstrations. This conference is attended by high-level (ministerial or higher) officials. The conference was designed to demonstrate in a non-technical way the application of Earth observation and in-situ data and modeling, as a means of justifying the continued funding of these activities.

[41] EURPOA, Earth & Space Week, http://europa.eu.int/comm/space/esw/index_en.htm.

3.0 POLICY INSTRUMENTS

Based on the preliminary Part 1 review, two air quality policy instruments were considered of highest potential and of most interest for the application of NASA Earth science resources. These instruments are the Convention on Long-Range Transboundary Air Pollution and the U.S.-Canada Bilateral Air Quality Executive Agreement. Two additional policy instruments with less potential for near-term application of NASA Earth science resources and less of a direct focus on air quality were also identified: the UN Convention to Combat Desertification, and the International Convention for the Prevention of Pollution from Ships. This section describes each of these instruments, focusing primarily on the instruments with the highest potential for NASA Earth science applications, and makes specific recommendation for NASA involvement. A summary of all instruments reviewed in Part 1 can be found in Appendix B.

3.1 Convention on Long-Range Transboundary Air Pollution

The Convention on Long-Range Transboundary Air Pollution (LRTAP) was the first international treaty to address air pollution.[42] In 1972, the UN Conference on the Human Environment established a set of principles, including that States (countries, as opposed to U.S. states) have "the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[43] Referring to this principle, LRTAP was negotiated to address transboundary air pollution primarily among States in Europe, former Soviet Union, and North America (see Figure 3-1). Asia, the Middle East, northern Africa, and central America are not currently included in LRTAP and its protocols due to socio-political issues; in addition, the southern hemisphere was not included due to different pollutant types (i.e., less industrial and more biomass burning sources) and the atmospheric separation of the two hemispheres. The 1979 Convention does not have binding commitments; rather, it sets out fundamental principles to reduce air pollution, cooperate on research and monitoring, exchange information, establish a Secretariat and executive body,

SUMMARY
Convention on Long-Range Transboundary Air Pollution

Location of Adoption:	Geneva, Switzerland
Year of Adoption:	1979
Overall Treaty Status:	Entered into force in 1983
Parties:	49 countries signed and ratified
Status in U.S.:	Signed in 1979, Ratified in 1981
U.S. Delegation Lead:	U.S. EPA, Office of Air and Radiation
Major Protocols:	Sulfur (1985, 1994)
	Nitrogen Oxides (1988)
	Volatile Organic Compounds (1991)
	Persistent Organic Pollutants (1998)
	Heavy Metals (1998)
	Acidification, Eutrophication, and Ground-level Ozone (1999)

[42] Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe, http://www.unece.org/env/lrtap/, accessed November 12, 2004.
[43] Declaration of the United Nations Conference on the Human Environment, Stockholm, 1972.

and administrative actions. LRTAP calls upon parties to reduce transboundary air pollution using the "best policies and strategies" and "best available technology which is economically feasible" without establishing any specific emissions reductions.

Figure 3-1. Ratification States of LRTAP.

Building from this original Convention, the signatories negotiated a series of protocols to address specific pollutants, beginning with regional transboundary air issues like acid precipitation and ground-level ozone, and ultimately addressing persistent organic pollutants, heavy metals, and multi-pollutant strategies. Typically, for each country, these protocols set specific emission targets for relevant pollutants, as well as designate or require other specific actions or types of actions.

3.1.1 Structure and Organization

3.1.1.1 LRTAP Secretariat and Executive Body

The Executive Secretary of the UN Economic Commission for Europe (UNECE) provides the Secretariat for the Executive Body of the Convention. It does so within the UNECE Environment and Human Settlements Division. The Secretariat convenes the meetings of the Executive Body, transmits information, and performs the functions assigned by the Executive Body. The LRTAP Executive Body consists of representatives of the contracting parties and is responsible for implementing and reviewing the Convention and establishing working groups and subsidiary bodies to carry out the work on implementation and development. The current chair of the Executive Body is Mr. Harald Dovland (Norway). Figure 3-2 is an organization chart of the major LRTAP subsidiary bodies.

The Working Group on Effects provides information on the degree and geographic extent of the impacts of major air pollutants on human health and the environment. Under this working group, there are International Cooperative Programme groups on modeling and mapping and on integrated monitoring for the Convention and its protocols.

The Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) was initiated in 1977 as a special program under the UNECE. The 1979 LRTAP Convention included EMEP as the steering body for data collection and scientific cooperation, and EMEP has operated under the Convention

since the Convention entered into force. EMEP's mandate is to provide sound scientific support for the Convention, in particular in the areas of:

- Atmospheric monitoring and modeling,
- Emission inventories and emission projections, and
- Integrated assessment modeling.[44]

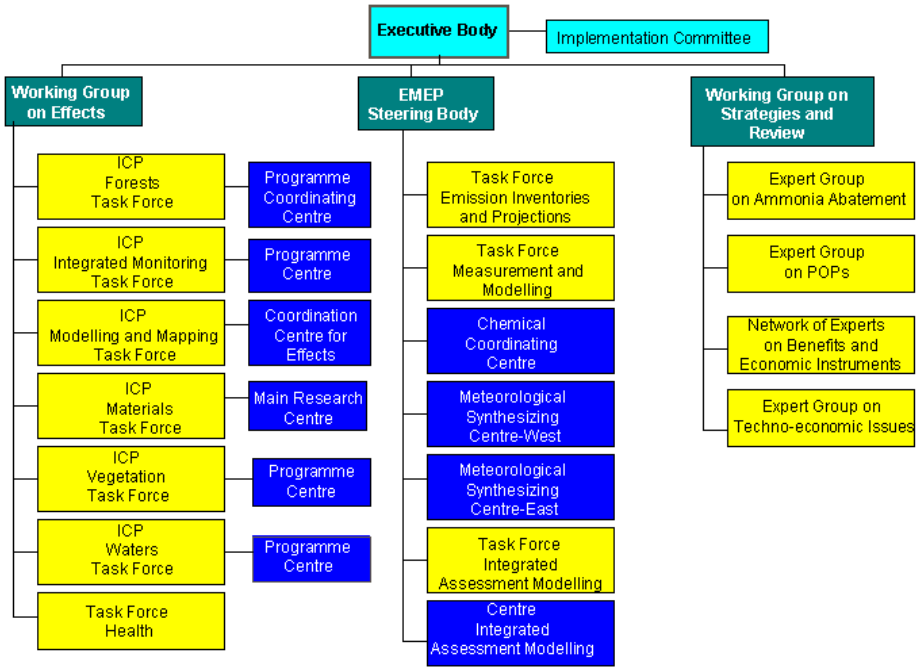

Figure 3-2: Organization Chart of the LRTAP Executive Body[45]

EMEP consists of three task forces (Emission Inventories and Projection, Measurement and Modeling, and Integrated Assessment Modeling) and four program centers:

- Chemical Coordinating Centre, which coordinates air quality and precipitation measurements;
- Meteorological Synthesizing Centre-West, which stores and distributes emissions and emission projections, as well as models sulfur, nitrogen, and particulates;
- Meteorological Synthesizing Centre-East, which models heavy metals and persistent organic pollutants; and
- Centre for Integrated Assessment Modeling, established in 1999 and which conducted integrated modeling.[46]

[44] Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), http://www.unece.org/env/emep/welcome.html, accessed November 12, 2004.
[45] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, Intergovernmental bodies, expert groups and scientific centres, http://www.unece.org/env/lrtap/conv/lrtap_o.htm, accessed November 12, 2004.
[46] What is EMEP? http://www.emep.int/emep_description.html, accessed November 12, 2004.

3.1.1.2 United States Involvement

The U.S. Environmental Protection Agency (EPA) leads the U.S. delegation to LRTAP, with the U.S. State Department providing support and final approval. EPA leadership is from the Office of Air and Radiation, specifically John Beale (Deputy Assistant Administrator, Office of Air and Radiation) who is former Vice Chair of the Executive Body of LRTAP, and William Harnett (Office of Air Quality Planning and Standards). There is no real participation by the United States in EMEP, which is predominantly European focused, although EMEP held a workshop in North America in April 2004, the first in over a decade.[47] NASA does not appear to be involved with UNECE aside from brief mentions on UNECE's website concerning the potential of remote sensing data.

3.1.2 Key Protocols

LRTAP has eight protocols is various stages of implementation. The key protocol of interest due to its multi-pollutant approach and its recent adoption is the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. Protocols on heavy metals and persistent organic pollutants recently came into force but relate to toxic substances that are difficult to monitor and model and are primarily controlled in the protocol through emission reduction and product controls. Appendix B of this report contains a short description of each of the protocols.

The purpose of the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone[48] is to minimize the adverse effects on human and environmental health from the long-distance transport of precursor air pollutants. The Protocol sets emission ceilings in each country for 2010 for four pollutants: sulfur, nitrogen oxides (NO_X), volatile organic compounds (VOCs), and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. The United States and Canada did not set specific ceilings, but promised to set limits upon ratification. The United States ratified this Protocol in November 2004; only two other countries' ratifications are required for the Protocol to come into force.[49]

The Protocol also sets limits for specific emission sources from a wide range of stationary and mobile sources, requiring the use of best available techniques to minimize emissions. Examples include cuts in VOC emissions from such products as paints and solvents, and specific measures to control ammonia emissions from agricultural production.

Other portions of the Protocol call for strategic planning, information and technology exchange, research, reporting, public awareness of pollutant levels and methods to reduce emissions, and administrative functions. Of note in Article 8, Research, Development, and

[47] EMEP Workshop on Particulate Matter Measurement & Modeling, New Orleans, LA, April 20-23, 2004, http://emep-neworleans-workshop.net/, accessed November 12, 2004.
[48] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1979. Full text available at http://www.unece.org/env/lrtap/full%20text/1999%20Multi.e.pdf.
[49] Air Pollution Protocol Boosted by U.S. Ratification, Press Release, United Nations Economic Commission for Europe, December 3, 2004.

Monitoring, is encouragement of activities to "improve understanding of the long-term fate of emissions and their impact on the hemispheric background concentrations of sulphur, nitrogen, volatile organic compounds, ozone and particulate matter, focusing, in particular, on the chemistry of the free troposphere and the potential for intercontinental flow of pollutants."[50]

3.1.3 Technical Issues

EMEP is currently validating a unified Eulerian model for monitoring PM_{10} and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than or equal to 10 and 2.5 microns, respectively). The model is underestimating total concentrations due to incomplete process and emission inputs; correlations are averaging 0.68 for 17 stations.[51] The LRTAP Task Force on Health Effects of Air Pollution recommended further development of the model, as well as increased efforts to better monitor particulate matter (PM), so the model may be used to track progress from 2000 to 2010.

Regional Air pollution INformation and Simulation (RAINS) is the other key model for the development and monitoring of LRTAP Protocols and for the Clean Air for Europe (CAFE) programme of the European Commission. The International Institute for Applied Systems Analysis (IIASA), a nongovernmental research institute, developed RAINS as a unique model that integrates a complete set of decision products on a 50 km grid: emissions of sulfur dioxide (SO_2), NO_X, ammonia, VOCs, and PM; economic activities causing emissions (energy production and consumption, passenger and freight transport, industrial and agricultural production, solvent use, etc.); emission control options and costs; atmospheric dispersion of pollutants; and sensitivities of ecosystems and humans to air pollution.[52] It simultaneously addresses human and environmental health and costs of particulate pollution, acidification, eutrophication, and tropospheric ozone.

EMEP specifically defined its scientific needs in its 2000-2009 Strategy. For fine particulate matter (which they define as both PM_{10} and $PM_{2.5}$), their main goals are to:

- "Establish concentrations and population exposures of long-range transported fine particulate matter
- Calculate transboundary fluxes of fine particulate matter and their source attribution
- Develop interfaces with urban modeling and assessment
- Quantify the decreased visibility caused by fine airborne particulate matter in Europe
- Contribute to the determination of the effects of fine particulate matter on radiation forcing and climate change in the EMEP region."[53]

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[50] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1979. Full text available at http://www.unece.org/env/lrtap/full%20text/1999%20Multi.e.pdf.

[51] Modeling and Assessment of the Health Impact of Particulate Matter and Ozone, Summary report prepared by the joint Task Force on the Health Aspects of Air Pollution of the World Health Organization/European Centre for Environment and Health and the Executive Body, EB.AIR/WG.1/2004/11, June 14, 2004.

[52] Air Pollution (TAP), http://www.iiasa.ac.at/rains/.

[53] Strategy for EMEP 2000-2009, ECE/EB.AIR/73, Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), Convention on Long-range Transboundary Air Pollution, Economic Commission for Europe, Geneva, undated.

Needed improvements include national emission estimates, increased in-situ monitoring, chemical speciation, better aerosol dynamic modeling, and understanding of sources. For integrated assessment modeling, there is a strong need to "assess the atmospheric transport of substances, including intercontinental transport" [54] and calls for more collaboration with North America on global and transcontinental transport.

3.1.4 Opportunities and Recommendations to NASA for Further Involvement

The Gothenburg Protocol represents a departure from prior LRTAP Protocols since it addresses multiple pollutants (sulfur, NO_X, VOCs, ammonia) and effects, and requires significant (40-60%) reductions in emissions for European signatories.[55] In fact, its wide scope and scale as well as the recent expansion of the European Union has led to speculation that LRTAP will become either predominantly focused on European regulations and continue as a harmonizer of inter-regional policies (e.g., EU and Russia),[56] or broaden into a hemispheric or global approach.[57] Recent literature has suggested that LRTAP could serve as a template for a flexible intercontinental transport treaty if it assumes a hemispheric approach by including Asia and trans-Pacific as well as trans-Atlantic transport.[58] Aerosols and their precursors are considered the prime subject for the broader approach given their long-distance transport and impact on human health and global climate change models.

The Executive Body and its members discussed the vision of LRTAP at the Convention's 25th anniversary meeting, which took place in early December 2004 in Geneva. In a statement from EPA Administrator Michael Leavitt, the United States promoted "addressing transport across the northern hemisphere, coordinating with other regional bodies, and reducing particulate matter" under LRTAP.[59] One of the results of the meeting was the establishment of two new ad hoc organizational bodies of potential interest to NASA that indicate the intentions of the LRTAP Executive Body for a hemispheric approach and for addressing particulate matter:

- A task force on the hemispheric transport of air pollution, headed by the United States and the European Community, to "plan and conduct the technical work necessary to develop a fuller understanding of the hemispheric transport of air pollution for consideration in the reviews of protocols to the Convention."[60]

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[54] Ibid.

[55] Wettestad, Jørgen, The 1999 Multi-Pollutant Protocol: A Neglected Break-Through in Solving Europe's Air Pollution Problems?, in Olav Schram Stokke and Øystein B. Thommessen (eds.), *Yearbook of International Co-operation on Environment and Development 2001/2002*, London: Earthscan Publications, 2001, 35-41.

[56] Ibid.

[57] Strategy for EMEP 2000-2009, ECE/EB.AIR/73, Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), Convention on Long-range Transboundary Air Pollution, Economic Commission for Europe, Geneva, undated.

[58] Halloway, T., A. Fiore, and M. Hastings, Intercontinental transport of air pollution: will emerging science lead to a new hemispheric treaty? *Environmental Science and Technology* 2003;37:4535-4542.

[59] Statement from Michael O. Leavitt on the 25th Anniversary of the Convention on Long-Range Transboundary Air Pollution, U.S. Environmental Protection Agency, November 2004.

[60] Report on the Twenty-Second Session of the Executive Body, Addendum, ECE/EB.AIR/83/Add.1, Executive Body for the Convention on Long-range Transboundary Air Pollution, Economic and Social Council, Economic Commission for Europe, United Nations, 16 December 2004.

- An expert group on particulate matter, headed by Germany and the United Kingdom, to assess current control of particulate matter by protocols of the Convention, review current work on particulate matter, and to consider technical and non-technical requirements to aid Parties in developing measures (e.g., changes to current protocols or new protocols) to control particulate matter. [61]

The creation and subsequent recommendations of the hemispheric transport task force, which may result in LRTAP being broadened into a hemispheric or global treaty by engaging Asia and other countries, will increase the involvement of the EPA and the United States in general and represents a timely opportunity for NASA involvement. Since a hemispheric or global approach will require information over oceans and in regions with minimal ground-based monitors, NASA capabilities in remote sensing and global models could significantly contribute. As the expert group on PM begins its work, the limited number of PM monitors and the coarse scale (50 km grid) of models in Europe represent an opportunity to use satellite remote sensing data, particularly aerosol optical depth, to validate models and monitor progress. This would be most applicable through the multi-pollutant Gothenburg Protocol or future particulate-based protocols.

Administratively, NASA should coordinate its participation through EPA since EPA represents the U.S. delegation, is leading the new task force studying hemispheric transport, and is an advocate of the hemispheric approach. EPA has expressed interest in working with NASA and using NASA Earth science resources in support of the hemispheric task force.[62] International policy organizations, including the research organization EMEP, and their developing relationship with ESA, are well-established and may resist new players. Working with EPA would be considered the proper channel for NASA involvement, and would increase the likelihood of success. The recent U.S. ratification of the Gothenburg Protocol, and the expectation that it will enter into force within the next year or two, present an opportunity for NASA involvement in a relatively new Protocol. The United States lead on the task force to study hemispheric transport represents an excellent opportunity for NASA involvement in the development of new Protocols related to a global approach to air pollution, particularly PM.

From a technical perspective, there is a role for NASA in monitoring and modeling in order to assess existing protocols (especially Gothenburg), developing new priorities for future protocols, and increasing understanding of air pollutant transport across and between continents. Specific NASA resources that should be explored for use in supporting LRTAP are:

- *Moderate Resolution Imaging Spectroradiometer (MODIS)*[63] sensors on Terra and Aqua platforms have existing aerosol products (MOD04 and MYD04) that could contribute to understanding the transport of PM, including sulfate and to a lesser extent nitrate. MODIS would be particularly useful in the development of a new hemispheric treaty or a

[61] Ibid.
[62] Conversation with Terry Keating, U.S. Environmental Protection Agency, 6103A, Ariel Rios Building 1200 Pennsylvania Avenue, N. W., Washington, DC 20460, (202) 564-1174, keating.terry@epa.gov, January 21, 2005.
[63] http://modis-atmos.gsfc.nasa.gov/.

new PM annex, which would build from application to the Gothenburg Protocol for sulfur. MODIS aerosol optical depth products have been validated for this use and would be particularly valuable in understanding trans-Atlantic and other long-distance transport.

- *Visible Infrared Imaging Radiometer Suite (VIIRS)*[64] on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project spacecraft to be launched in 2006, will provide an excellent suite of data for atmospheric monitoring, such as aerosol optical depth. It will also provide continuity of data from the MODIS and SeaWiFS research instruments and will be useful for monitoring hemispheric PM transport.

- The *Ozone Monitoring Instrument (OMI)*[65] and *Tropospheric Emission Sounder (TES)*[66], both on the Aura platform, have products in development that may provide valuable information for LRTAP, particularly ozone, NO_2, and SO_2. While the spatial resolution is fairly coarse (e.g., 13 to 24 km^2), it is sufficient for comparison to EMEP models (50 km grid resolution) and for evaluation of long-distance transport. OMI builds on the Total Ozone Mapping Spectrometer (TOMS) sensors, but should provide better information about tropospheric ozone as well as other gases of interest.

- *Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP)* on the Cloud-Aerosol Lidar and Infrared Pathfinder Spaceborne Observations (CALIPSO)[67] mission will provide the ability to place the aerosols within the vertical column. Used in conjunction with 2-dimentional aerosol optical depth sources, such as MODIS, and ground-based monitoring, CALIPSO could help in understanding the height at which pollution is transported and how and when it mixes into the boundary layer.

- The *AERONET (AErosol RObotic NETwork)*[68] program and its associated optical ground-based aerosol monitoring networks are global and are already widely applied for international study of air pollution. AERONET also has established partners in Europe. Information from this network could be used in conjunction with ground-based and satellite data in general support of the LRTAP. Similarly, the *Micro Pulse Lidar Network (MPLNET)*[69] could be used in conjunction with satellite sensors and European lidar networks to study specific transport events.

- Atmospheric models from NASA, such as *Regional Air Quality Modeling System (RAQMS)*[70] for ozone and *Goddard Chemistry Aerosol Radiation and Transport (GOCART)*[71] for aerosols could also be applied toward increasing understanding of transport. Since EMEP depends heavily on its own models, NASA should first work

[64] http://www.ipo.noaa.gov/Technology/viirs_summary.html and http://science.hq.nasa.gov/missions/satellite_58.htm.
[65] http://aura.gsfc.nasa.gov/instruments/omi/introduction.html.
[66] http://aura.gsfc.nasa.gov/instruments/tes/introduction.html.
[67] http://www-calipso.larc.nasa.gov/.
[68] http://aeronet.gsfc.nasa.gov/.
[69] http://mplnet.gsfc.nasa.gov/.
[70] http://asd-www.larc.nasa.gov/new_AtSC/raqms.html.
[71] http://code916.gsfc.nasa.gov/People/Chin/gocartinfo.html.

with EPA to determine the applicability of these models for LRTAP. However, it seems reasonable that they could support both the Gothenburg Protocol implementation and the investigation of hemispheric transport.

NASA should first initiate contact with the EPA delegation in order to determine the data and information needs for the implementation of the Gothenburg Protocol, for future Protocols, and for supporting the task force on hemispheric transport. This contact should be made in the spring of 2005 as progress in these areas under LRTAP is expected in the next year.

3.2 United States-Canada Bilateral Air Quality Executive Agreement

The U.S.-Canada Bilateral Air Quality Executive Agreement[72] (Agreement) establishes a formal and flexible method of addressing transboundary air pollution and lays the groundwork for cooperation on a variety of air quality issues. The Agreement lays out overall air quality objectives and specific requirements for Canada and the United States, including regular communication, exchange of information, and consultation and settlement of issues of concern.

SUMMARY
U.S.-Canada Bilateral Air Quality Executive Agreement

Location of Adoption:	Ottawa, Canada
Year of Adoption:	1991 (Annexes 1 & 2), 2000 (Annex 3)
Overall Treaty Status:	Entered into force in 1991
Parties:	Canada and U.S.
Status in U.S.:	In force
U.S. Delegation Lead:	U.S. State Department, with U.S. EPA and other Federal and state support
Major Annexes:	Annex 1, Acid Rain Annex 2, Scientific and Technical Activities and Economic Research Annex 3, Ozone
Potential Annex Under Study:	Particulate Matter

A bi-annual progress report required under the Agreement was released in November 2004.[73] This report reviews major actions taken by both countries to address transboundary air pollution over the last two years, and specifically focuses on each country's progress in achieving the requirements under Annex 1 (Acid Rain) and Annex 3 (Ozone). The report also includes highlights from a joint technical report expected to be released in early 2005 on inhalable particles in the transboundary region, in support of decisionmaking on future updates to the Agreement. This section describes the structure and organization

[72] United States-Canada Bilateral Air Quality Agreement, http://www.ijc.org/rel/agree/air.html. Also see U.S. EPA Clean Air Markets, US-Canada Air Quality Agreement, http://www.epa.gov/airmarkets/usca/index.html.
[73] United States-Canada Air Quality Agreement, Progress Report 2004, http://www.epa.gov/airmarkets/usca/airus04.pdf. The International Joint Commission (IJC), established as part of the Boundary Waters Treaty of 1909, established the International Air Quality Advisory Board to identify and provide advice on air pollution issues with transboundary implications. With respect to the bi-annual Air Quality Committee reports, the International Air Quality Advisory Board is responsible for soliciting public input on issued reports and relaying this input to the IJC.

established by the Agreement, key existing annexes and a potential particulate matter annex currently under study, technical issues, and recommendations to NASA for further involvement.

3.2.1 Structure and Organization

The Agreement establishes a bilateral Air Quality Committee (Committee) that is responsible for coordinating the overall implementation of the Agreement. The Committee is required to be composed of an equal number of members representing the United States and Canada. The Committee meets at least annually, prepares a joint progress report every two years, and conducts a regular five-year review and assessment of the Agreement (the last five-year review was conducted in 2002). While not labeled as a Secretariat in the Agreement, the Committee performs the typical functions of a Secretariat of a multilateral agreement.

The Committee has the following two subcommittees that meet separately several times per year, and have more informal interactions on an ongoing basis:

- The Subcommittee on Scientific Cooperation (co-chaired by EPA, Office of Research and Development [ORD] staff Bill Russo) that focuses on how to improve the tracking of the Agreement and measure its effectiveness.

- The Subcommittee on Program Monitoring and Reporting (co-chaired by EPA, Office of Atmospheric Programs [OAP] Director Brian McLean).

The Agreement also creates new duties for the International Joint Commission (IJC), a bilateral group established as part of the Boundary Waters Treaty of 1909. The IJC is required to solicit and collect public comments on the biennial joint progress report, submit a synthesis of the comments to the Committee, and make the comment synthesis publicly available.

3.2.1.1 United States Involvement

The U.S. Co-chair of the committee is Claudia McMurray, Deputy Assistant Secretary of the Environment, U.S. State Department. The other U.S. representatives on the committee are from EPA, NOAA, Department of the Interior, Department of Energy, and New York State Department of Environmental Conservation. Specific U.S. contacts are provided in the recommendations section (3.2.4) that follows.

3.2.2 Key Annexes

In addition to the annexes addressing specific transboundary air quality issues described below, the Agreement fosters a spirit of cooperation between the two countries for addressing transboundary air pollution. For example, the Agreement requires notification between the countries for new or modified sources anticipated to have cross-border air quality impacts. The United States has notified Canada of 34 such sources since the requirement began in 1994, and Canada has notified the United States of 37 such sources. In addition, the collaborative work of the Air Quality Committee and its associated subcommittees (discussed further below), and the joint preparation of biennial progress reports and five-year program reviews, illustrate the cooperation fostered by the Agreement.

3.2.2.1 Annex 1, Acid Rain

Annex 1, the Acid Rain Annex, focuses on the commitments of both nations to reduce SO_2 and NO_x emissions and to monitor utility emissions. Annex 1 does not create new emission targets or timelines in the United States, but rather codifies existing requirements under U.S laws and regulations in a transboundary context and furthers the cooperation between the two countries in addressing acid rain. Specifically, Annex 1 requires SO_2 and NO_x emission reductions, emissions monitoring, prevention of air quality deterioration, and protection of visibility.

With respect to emissions monitoring, both countries are required to measure and record emissions from specified electric utility generating units with continuous emission monitoring systems (CEMS) or with a method of comparable effectiveness. Both countries have met this monitoring requirement and have also established the required objectives for emission limitations or reductions, programs to implement these objectives, and timetables for implementation.

3.2.2.2 Annex 2, Scientific and Technical Activities and Economic Research

Under Annex 2, the Scientific and Technical Activities and Economic Research Annex, Canada and the United States agree to coordinate their air pollution monitoring networks; use compatible formats and methods for monitoring and reporting; and cooperate and exchange information about the causes and effects of air pollution and the use of market-based programs, such as the U.S. Acid Rain Program, to address air pollution issues. Procedures for all U.S. and Canadian networks are now standardized[74] and contribute to an integrated, consistent dataset.[75] Annex 2 (Sections 3c and 3f) includes the following:

> "The Parties agree to cooperate and exchange information with respect to:
> - …their development and refinement of atmospheric models for purposes of determining source receptor relationships and transboundary transport and deposition of air pollutants;
> - …any other scientific and technical activities or economic research that the Parties may agree upon for purposes of supporting the general and specific objectives of this Agreement."[76]

The cooperation and exchange of information required by Annex 2 highlight the potential opportunity for use of Earth observation satellite information and NASA models in cooperation with Canada to assess transboundary issues and the effectiveness of the Agreement. Further recommendations for NASA involvement with the Subcommittee on Scientific Cooperation are provided in the recommendations section (3.2.4) that follows.

[74] Ibid.
[75] Database available to the public at http://www.msc.ec.gc.ca/natchem/index_e.html.
[76] United States-Canada Bilateral Air Quality Agreement, http://www.ijc.org/rel/agree/air.html. Also see U.S. EPA Clean Air Markets, US-Canada Air Quality Agreement, http://www.epa.gov/airmarkets/usca/index.html.

3.2.2.3 Annex 3, Ozone

Annex 3, the Ozone Annex,[77] focuses on the control of transboundary ground-level ozone by committing the two nations to reducing emissions of NO_x and VOCs. Annex 3 establishes a transboundary region, known as the Pollutant Emission Management Area (PEMA), which includes central and southern Ontario, southern Quebec, 18 U.S. states, and the District of Columbia. The provinces and states within the PEMA region are the areas of primary concern for the impact of transboundary ozone. Like Annex 1, Annex 3 does not create new emission targets or timelines in the United States, but rather commits the United States to existing requirements for NO_x and VOC reduction, and creates reporting requirements as part of a cooperative approach to the problem. Both countries are on track for implementation of the requirements committed to in Annex 3. Annex 3 (Part V, Sections C and D) includes the following:

> "Beginning in 2002, as part of the biennial progress reports, the Parties agree to provide the following ambient air quality information:
>
> - Ambient ozone concentrations, reported in the form of the applicable standards
> - 10-year trends in ambient ozone concentrations
> - Ambient VOC concentrations
> - 10-year trends in ambient VOC concentrations
> - Ambient NOx concentrations
> - 10-year trends in ambient NOx.
>
> The ambient air quality information listed above shall be reported for all relevant monitors located within 500 km of the border between Canada and the lower 48 states of the United States."[78]

The 2004 Progress Report explains that both countries have extensive networks to monitor ground-level ozone and its precursors, while acknowledging certain areas with a lower density of monitors. There is a potential opportunity for use of earth observation satellite information and NASA models in cooperation with Canada to fulfill the Annex 3 requirements and assess its overall effectiveness in achieving the desired environmental outcome. Further recommendations for NASA involvement (specifically with the Subcommittee on Scientific Cooperation) are provided in the recommendations section (3.2.4) that follows.

3.2.2.4 Potential Future Annex, Particulate Matter

The United States and Canada recently prepared a joint technical report (expected to be released in early 2005) on inhalable particles in the transboundary region, in support of decisionmaking on future updates to the Agreement. This joint technical report, prepared as a result of the 1997 Joint Plan of Action for Addressing Transboundary Air Pollution, addresses key objectives identified in three binational workshops for development of a particulate matter science assessment. As summarized in the 2004 Progress Report, these objectives are:

- Identify whether a fine PM problem exists in the border region, based on current standards.

[77] Environment Canada, Annex 3, http://www.ec.gc.ca/air/can_usa_e.html.

[78] United States-Canada Bilateral Air Quality Agreement, http://www.ijc.org/rel/agree/air.html. Also see U.S. EPA Clean Air Markets, US-Canada Air Quality Agreement, http://www.epa.gov/airmarkets/usca/index.html.

- Identify the extent of the problem; if standards are exceeded, where, when, and by how much?
- Describe the PM issue in terms of geographic regions (e.g., West, Central, East).
- Identify PM precursors of concern on a regional or sub-regional basis.
- Describe source regions of PM and its precursors in the context of geographic regions (i.e., West, Central, East).
- Describe emissions of PM precursors.
- Identify the effect of current and proposed emission reduction scenarios on fine PM levels in North America.

The joint technical report indicates that current ambient levels of $PM_{2.5}$ in the U.S.-Canada border region exceed the standards set for $PM_{2.5}$, mostly in the eastern portion of the border. The report concludes that $PM_{2.5}$ in the border region consists of (in order of contribution): organic/black carbon, sulfate, nitrate, ammonium, soil dust, and trace elements. Source receptor analyses indicate that several areas contribute to elevated PM levels in eastern North America. Projected $PM_{2.5}$ reductions were estimated with model scenarios using shared emission scenarios for 2010 and 2020 (U.S. work used the REMSAD model; Canadian work used the AURAMS model).

Further development on this Annex is pending finalization of the Clean Air Interstate Rule (CAIR), which will address NO_x and SO_x transport between U.S. states, focused on states whose power plant emissions are significantly contributing to fine particle and ozone pollution in other downwind states in the eastern United States.[79] The CAIR was proposed by EPA on January 30, 2004; it was originally expected that EPA could issue a final rule by the end of 2004. There is a possibility that CAIR could be replaced with legislative action.[80] Once the CAIR or other related legislation is finalized, it could provide a basis for negotiation of a PM Annex. Like the Acid Rain and Ozone Annexes, a PM Annex would not be likely to create new emission targets and timelines in the U.S., but rather would codify existing requirements under U.S laws and regulations in a transboundary context, and would further the cooperation between the two countries in addressing this issue. It is likely that the actual negotiations of a PM Annex will not occur until late 2005 or 2006. However, in the meantime, there will likely be further assessment and planning for this PM Annex.

3.2.3 Technical Issues

Satellite sensors and existing data products from NASA's Earth Observing System represent a unique monitoring product that can directly support the Agreement. Building on the application of these sensors to support the CAIR, the Agreement can use satellite remote sensing to identify the spatial and temporal extent of pollutant transport across the border and monitor accountability of current and future annexes.

[79] Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Interstate Air Quality Rule), Federal Register 69(20): 4566-4650, January 30, 2004, http://www.epa.gov/interstateairquality/rule.html.
[80] Samuelsohn, Darren; E&E Daily online, EPA may face congressional pressure to delay CAIR release, http://www.eenews.net/EEDaily.php, November 15, 2004.

Satellites are the ideal monitoring sensors to provide comprehensive geospatial information on aerosol extent, monitor motion and transport during PM events across the U.S.-Canada border, and, in conjunction with ground-based monitors, indicate the intensity of PM compared to the standards. Real-time monitoring and quantitative analysis of existing satellite data can be used to understand the PM issue in the U.S.-Canada border region. Current and new sensors can be used to track accountability of new regulations and current and future annexes.

MODIS sensors were used to support the development of the CAIR by EPA's Office of Air Quality Planning and Standards, and thus could be applicable to supporting the Bilateral Agreement. True color images were used to visualize and monitor pollutant transport events, and detailed statistical analysis was conducted to document that MODIS aerosol optical depth had a significant relationship to $PM_{2.5}$ concentrations at ground-level, particularly in the eastern United States and for sulfates and smoke.[81] The MODIS sensor true color image in Figure 3-3 shows a combination haze/smoke event across the border in September 2003; Figure 3-4 shows how aerosol optical depth can be used to quantify the intensity of an event and be used in conjunction with back trajectory models. Figure 3-5 is an integration of true color imagery and aerosol optical depth data for North America during a major fire event.

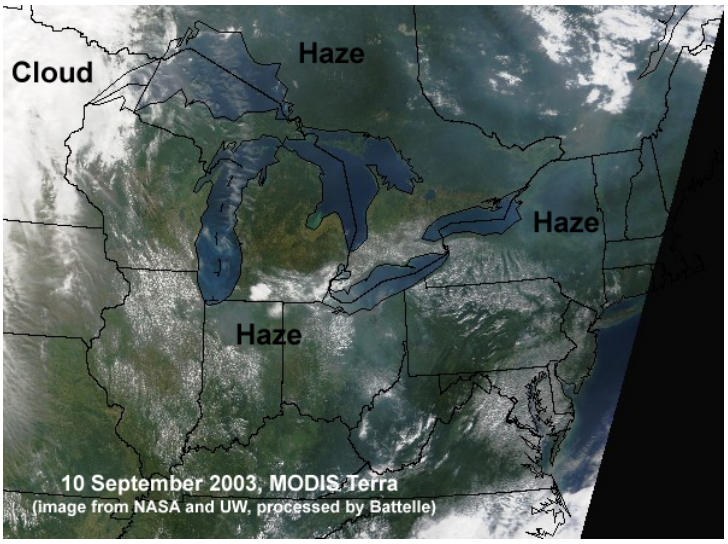

Figure 3-3. Haze/smoke transport event as seen by MODIS Terra.

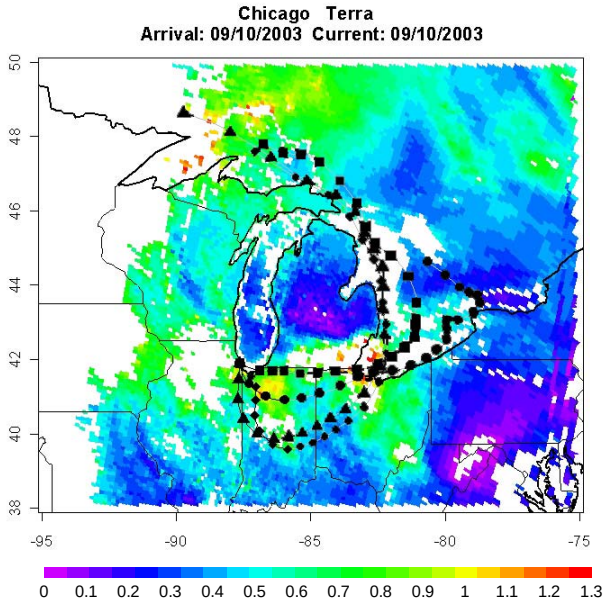

Figure 3-4. MODIS Terra aerosol optical depth on 10 September 2003 with 72 hour HYSPLIT back trajectories.

3.2.4 Opportunities and Recommendations to NASA for Further Involvement

As demonstrated by the Agreement excerpts in the previous sections, the Agreement does not provide specifics on the types of monitoring and data needs for evaluating the Agreement, but rather focuses on general cooperation between the United States and Canada and establishes a timetable for evaluation of progress. Therefore, the Committee and its subcommittees are

[81] Engel-Cox, J., C. Holloman, B. Coutant, and R. Hoff, Qualitative and quantitative evaluation of MODIS satellite sensor data for regional and urban scale air quality, Atmospheric Environment, May 2004;38:2495-2509.

given considerable latitude in determining the monitoring and evaluation needs for the Agreement, and would be a good starting point for NASA consultations. Through these consultations, NASA should seek to determine the precise needs of the Committee with respect to monitoring and evaluation of the Agreement and analysis to support a potential PM Annex. The development of a new PM annex provides a timely opportunity for NASA involvement over the next few years, and NASA should begin the process to work with EPA on the current and future potential of satellite Earth observation data for this application.

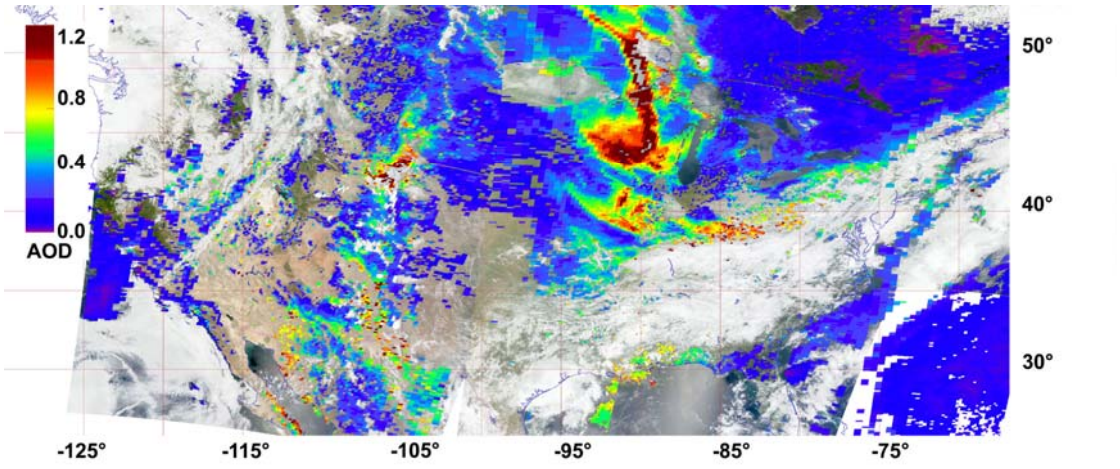

Figure 3-5. MODIS Terra true color and aerosol optical depth data, 28 June 2002.

Conversations with Ms. Rona Birnbaum,[82] who participates on the Committee, indicated that there would be interest in the use of satellite Earth observation data for the Agreement and that the best initial forum for discussion of this topic is the Subcommittee on Scientific Cooperation. NASA interaction with the committee should be conducted through EPA, specifically Ms. Birnbaum and Mr. William Russo (EPA ORD), the Co-chair. The Subcommittee on Scientific Cooperation may be of particular interest to NASA because of its focus on how to improve the tracking of the Agreement and measure its effectiveness. Current discussions in this Subcommittee are focused on air quality modeling.[83] The Committee meets at least once per year; the last meeting was scheduled for December 2004. The work of the Committee and subcommittees is organized around annual workplans. Through introduction to the Subcommittee on Scientific Cooperation, NASA should request that the use of Earth observation satellite data be incorporated into a future workplan.

Another opportunity exists for NASA staff to become involved with the International Air Quality Advisory Board of the International Joint Commission (IJC). Preliminary conversations with staff from the IJC and Environment Canada indicate interest in NASA involvement and the

[82] Conversation with Rona Birnbaum, U.S. Environmental Protection Agency, Clean Air Markets Division, 6204J, Ariel Rios Building, 1200 Pennsylvania Avenue, N. W., Washington, DC 20460,birnbaum.rona@epa.gov, 202-343-9076, November 16, 2004.

[83] Conversation with Terry Keating, U.S. Environmental Protection Agency, 6103A, Ariel Rios Building 1200 Pennsylvania Avenue, N. W., Washington, DC 20460, (202) 564-1174, keating.terry@epa.gov, November 5, 2004.

application of NASA resources in monitoring cross-border transport, starting with technical and policy meetings in the spring and summer 2005.[84]

Challenges for NASA will include determining the precise needs of the Committee with respect to monitoring and evaluation of the Agreement, understanding the past and ongoing work done to support the Agreement, and building upon that work to meet the specified needs through application of readily available NASA satellites, data, and models and development of future missions. Depending on the outcome of consultations with the Committee, NASA should decide and clearly communicate whether to offer a complete model or product that can be used to answer specific questions regarding the Agreement, or simply offer either raw or processed data. Offering a complete model or product could be an easier "sell" and will demonstrate the current applicability of satellite data (countering concerns by some in the community that air quality satellite data is research-oriented, preliminary, and/or unproven for air quality applications).

NASA should consider both short- and long-term ways to support the Agreement. In the short term, NASA may be able to build on the recent particulate matter scientific assessment by providing a model or product to help define the spatial and temporal extent of the transboundary inhalable particle air quality problem, in support of a potential PM Annex. Also in the short term, NASA may be able to help assess the degree to which the implementation of the Acid Rain and Ozone Annexes are achieving the desired environmental outcomes (a measure of accountability). In the long term, NASA may be able to provide a model or product that can be used to assess the ongoing effectiveness of all Agreement commitments (including the potential PM Annex) and help develop and assess management options for the U.S.-Canada airshed. NASA should also communicate that future models and products are under development, and that this development could be guided by input from the Air Quality Committee on the monitoring and assessment needs of the Agreement.

From a technical perspective, existing NASA sensors and models can be used to monitor sulfate and to a lesser extent nitrate transport across boundaries. As exploration of a future PM annex begins, application of aerosol optical depth products could be significant. With the launch of Aura and as techniques for monitoring tropospheric ozone develop, support for Annex 3 may be able to increase. Specific NASA resources that should be explored for use in supporting this Agreement are:

- *Moderate Resolution Imaging Spectroradiometer (MODIS)*[85] on Terra and Aqua platforms, particularly existing aerosol products (MOD04 and MYD04) could contribute to understanding of the transport of PM, supporting the development of the new PM annex. MODIS aerosol optical depth products have been validated for this use and would be particularly valuable in understanding and quantifying cross-border transport. NASA should partner with EPA to develop relevant products for quantifying cross-border transport using aerosol optical depth over land.

[84] Conversation with John McDonald, International Joint Commission, mcdonaldj@windsor.ijc.org, and Ann McMillan, Environment Canada, ann.mcmillan@ec.gc.ca, January 21, 2005.
[85] http://modis-atmos.gsfc.nasa.gov/.

- *Visible Infrared Imaging Radiometer Suite (VIIRS)*[86] on the NPOESS Preparatory Project spacecraft to be launched in 2006, will provide continuity of data from the MODIS and SeaWiFS research instruments and will be useful for monitoring cross-border PM transport.

- The *Ozone Monitoring Instrument (OMI)*[87] and *Tropospheric Emission Sounder (TES),*[88] both on the Aura platform, have products in development that may provide valuable information for the Agreement, particularly ozone for Annex 3 and NO_2 and SO_2 for Annex 1. The spatial resolution may be too coarse and the implementation of these Annexes too fully developed to benefit from these new data sources. NASA should continue to pursue their product development and investigate with EPA their applicability to provide new information for the Agreement.

- *Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP)* on the Cloud-Aerosol Lidar and Infrared Pathfinder Spaceborne Observations (CALIPSO)[89] mission will provide the ability to place the aerosols within the vertical column. Used in conjunction with 2-dimensional aerosol optical depth sources, such as MODIS, and ground-based monitoring, CALIPSO could help in understanding the height at which pollution is transported and how and when it mixes into the boundary layer.

- Atmospheric models from NASA, such as *Regional Air Quality Modeling System (RAQMS)*[90] for ozone and *Goddard Chemistry Aerosol Radiation and Transport (GOCART)*[91] for aerosols could also be applied toward increasing understanding of transport between the United States and Canada.

Working closely with EPA, the Air Quality Committee, and its subcommittees, the following are specific actions that could be taken to increase understanding and monitoring of PM transport on the U.S.-Canada border, in support of a potential PM Annex:

- *Define Specific Needs.* In a collaborative process, define research questions and information needs of the Agreement that could be satisfied with the application of satellite remote sensing data, including identifying the extent of the PM problem and describing the PM geographic source regions.

- *Near Real-time Monitoring and Analysis.* Visualize events in real time and create a website with annotated satellite and ground-based imagery and data that focus on U.S.-Canada PM transboundary issues. Integrate trans-border air emissions forecasting into existing systems developed by NASA and partners, such as the Infusing satellite Data into Environmental Applications (IDEA) site.[92]

[86] http://www.ipo.noaa.gov/Technology/viirs_summary.html and http://science.hq.nasa.gov/missions/satellite_58.htm.
[87] http://aura.gsfc.nasa.gov/instruments/omi/introduction.html.
[88] http://aura.gsfc.nasa.gov/instruments/tes/introduction.html.
[89] http://www-calipso.larc.nasa.gov/.
[90] http://asd-www.larc.nasa.gov/new_AtSC/raqms.html.
[91] http://code916.gsfc.nasa.gov/People/Chin/gocartinfo.html.
[92] http://idea.ssec.wisc.edu/

- *Event Analysis.* Process imagery and data to assess PM transport during major events.

- *Quantitative Analysis.* Quantitative study of both key events and routine transport in conjunction with ground-based concentration data. Develop mass flux estimates across the U.S.-Canada border.

- *Integrated Datasets and Models.* Development of integrated datasets and models that would support monitoring of small-scale transport. Use satellite data in conjunction with models such as GOCART to determine flow paths from one nation to the other.

- *Accountability of Existing Annexes.* With new NASA sensors that can monitor ozone and other chemical species, investigate their use to study accountability under the Ozone and Acid Rain annexes.

3.3 Desertification

3.3.1 Background and Monitoring

The UN Convention to Combat Desertification, Particularly in Africa[93] (UNCCD) is intended to mitigate desertification and drought through improved land use practices, increased local participation in land use planning, and mobilization and coordination of funding assistance. The UNCCD is relevant to air quality because changes in land use such as desertification can contribute significantly to generation of airborne particulate matter.

SUMMARY
United Nations Convention to Combat Desertification, Particularly in Africa (UNCCD)

Location of Adoption:	Paris, France
Year of Adoption:	1994
Overall Treaty Status:	Entered into force in 1996
Parties:	191 including the U.S.
Status in U.S.:	Signed in 1994, Ratified in 2000
U.S. Delegation Lead:	U.S. State Department Lead, U.S. Agency for International Development (USAID) implements the UNCCD abroad. U.S. Departments of the Interior (Bureau of Land Management) and Agriculture carry out program activities in support of the implementation of the Convention.
Major Annexes:	
Annex I	Regional Implementation Annex for Africa
Annex II	Regional Implementation Annex for Asia
Annex III	Regional Implementation Annex for Latin America and the Caribbean
Annex IV	Regional Implementation Annex for the Northern Mediterranean
Annex V	Regional Implementation Annex for Central and Eastern Europe

The UNCCD is targeted at inhabited drylands (e.g., parts of Africa; the American west; the Aral Sea in Russia; Argentina; and islands of the Caribbean, Indonesia, and the Mediterranean). The United States is a Party to this Convention since approximately 40% of the U.S. landmass is considered arid, semi-arid, or

[93] United Nations Convention to Combat Desertification, http://www.unccd.int/convention/text/convention.php.

dry sub-humid, and therefore susceptible to the processes of desertification. Globally, a third of the earth's surface is threatened by desertification (totaling over 4 billion hectares), a land degradation process caused by climate change and by human-induced factors such as over-cultivation, deforestation, and poor irrigation practices. Desertification occurs slowly, as different areas of degraded land spread and merge together, rather than through advancing desert. Since 1990, it is estimated that some 6 million hectares of productive land have been lost every year due to land degradation, causing income losses worldwide of US$ 42 billion per year.[94]

Countries affected by desertification are implementing the UNCCD by developing and carrying out national, sub-regional, and regional action programs. Criteria for preparing these programs are detailed in the treaty's five "regional implementation annexes": Africa (considered a priority), Asia, Latin America and the Caribbean, the Northern Mediterranean, and Central and Eastern Europe. Drawing on past lessons, the UNCCD states that these programs must adopt a democratic, bottom-up approach. The UNCCD's action programs are being developed through consultations among affected countries, donors, and intergovernmental and non-governmental organizations. Developed countries are expected to encourage the mobilization of substantial funding for the action programs and promote access to appropriate technologies and knowledge.

Like many other multilateral treaties, the UNCCD created a Secretariat (a UN entity to administer the UNCCD), and a Conference of Parties (the supreme body of the UNCCD mandated to make the decisions necessary to promote its effective implementation). The Secretariat is responsible for such tasks as compiling reports based on submissions from the parties, administering requests for technical assistance, and arranging the logistics for meetings of the parties. The UNCCD requires submittal of reports in accordance with the format and timelines established by the Conference of the Parties.

The UNCCD does not include a specific mechanism to monitor whether the parties are fulfilling their commitments or to enforce compliance, but does require the following:

> "The Conference of the Parties… shall make, within its mandate, the decisions necessary to promote its effective implementation. In particular, it shall: regularly review the implementation of the Convention and the functioning of its institutional arrangements in the light of the experience gained at the national, subregional, regional and international levels and on the basis of the evolution of scientific and technological knowledge…" (Part IV, Article 22.2).

In addition, national action programs are required to include features for monitoring and assessing ecological degradation to provide information on the process and dynamics of resource degradation, in order to facilitate better policy formulations and responses.

[94] Ten years on: UN marks World Day to Combat Desertification Press Release, http://www.unccd.int/publicinfo/pressrel/showpressrel.php?pr=press01_06_04.

3.3.2 Current U.S. Involvement

No new domestic programs were required in the United States to fulfill commitments under the UNCCD. The United States committed to provide an unspecified level of financial assistance to developing countries. When the convention was ratified in 2000, the United States was already providing financial assistance to countries experiencing desertification and drought. The President's letter transmitting the agreement to the Senate stated that the United States' obligations under the UNCCD would be met under existing law and ongoing assistance programs.

Bilaterally and regionally, the United States works with affected developing country Parties, local and international NGOs, and multilateral development banks on anti-desertification program activities, including education, community development, and capacity building, with the goal of empowering local people to combat desertification by identifying needs and solving problems themselves. In fiscal year 2001, the first year of U.S. participation, the U.S. Agency for International Development (USAID) provided $93.8 million in assistance to other nations, including $53.8 million to African countries. This support included assistance designed to mitigate desertification and drought by improving the capacity of communities and local institutions to use new technologies and tools to better manage agricultural lands and natural resource areas.[95] As demonstrated by the example projects below, other U.S. agencies, including NASA, also participate in programs targeted at desertification in developing countries.

Within USAID, the Multilateral Policy and Conventions Team[96] manages USAID engagement in a series of major environmental and agricultural undertakings. The Team works across USAID and with other U.S. government partners, NGOs, and international organizations. One example project addressing desertification is a collaborative effort of USAID and the U.S. Geological Survey (USGS). The West Africa Land Use and Land Cover Trends Project is a unique effort to document and quantify the impacts of the environmental and land resource trends in West Africa, with the goal of providing decisionmakers information about natural resource trends in the region and engaging them in planning sound and sustainable policy responses. The project provides training to environmental scientists from 15 West African countries in the analysis of satellite images from the Corona and Landsat satellite systems, allowing them to map and quantify the land use and land cover changes that have occurred across the region in the last 35 to 40 years.[97]

One of USAID's partners in the West Africa Land Use and Land Cover Trends Project is the USGS Earth Resources Observations (EROS) Data Center (EDC). For this project, the EDC provided satellite images from the Corona and Landsat satellite systems covering all of West

[95] Testimony Before the Committee on Environment and Public Works and the Committee on Foreign Relations, U.S. Senate, United States General Accounting Office, July 24, 2002, International Environment: U.S. Actions to Fulfill Commitments Under Five Key Agreements, Statement for the Record by John B. Stephenson, Director, Natural Resources and Environment, http://www.gao.gov/new.items/d02960t.pdf.

[96] The Multilateral Policy and Conventions Team is within the Bureau for Economic Growth, Agriculture, and Trade (EGAT), Office of Environment and Science Policy. We were unsuccessful in our attempts to contact Franklin Moore (fmoore@usaid.gov) and Belindia Hicks (bhicks@usaid.gov) within this Team.

[97] USAID, West Africa Land Use and Land Cover Trends Project, http://www.usaid.gov/missions/warp/fdsecurity/emonitoring/index.htm.

Africa at four points in time (the 1960s, 1970s, 1980s, and 2000s). The EDC[98] is a data management, systems development, and research field center for the USGS National Mapping Division. The EDC has approximately 600 government and contractor employees, including employees at the NASA Ames Research Center in Moffett Field, California. As EDC's partners, NASA and USGS work together on a number of projects, including the Land Processes Distributed Active Archive Center[99] (LP DAAC) established as part of NASA's Earth Observing System (EOS) Data and Information System (EOSDIS) initiative to process, archive, and distribute land-related data collected by EOS sensors.

NASA and the EDC are involved in a second project[100] addressing desertification through the Global Resource Information Database (GRID). One GRID office is located at the EDC in Sioux Falls, South Dakota, and is operated in cooperation with the UN Environment Program, NASA, USGS, U.S. Forest Service and EPA, guided by an advisory committee from Canada, Mexico and the United States.

3.3.3 Global Activities and Information Sources

As discussed in Section 2.2, ESA has conducted a pilot project regarding the use of Earth observations to support this agreement through its TESEO initiative.

In addition, the UN System-wide Earthwatch mechanism[101] is a broad UN initiative to coordinate, harmonize and catalyze environmental observation activities among all UN agencies for integrated assessment purposes. Earthwatch was established at the 1972 UN Conference on the Human Environment in Stockholm and reinforced by the 1992 UN Conference on Environment and Development in Rio de Janeiro and its Agenda 21 chapter on Information for Decision Making. The Earthwatch website includes sites with links to recent papers relevant to desertification[102] and remote sensing.[103]

The Committee on Science and Technology (CST) was established as a subsidiary body of the UNCCD Conference of the Parties to provide it with information and advice on scientific and technological matters related to combating desertification and mitigating the effects of drought. The CST is composed of government representatives competent in the fields of expertise relevant to combating desertification and mitigating the effects of drought. It is multi-disciplinary and open to the participation of all Parties. It meets in conjunction with the ordinary sessions of the Conference of the Parties. The last Meeting of the Bureau of the Sixth Session of the Conference of the Parties was held in Germany on June 6, 2004.

[98] USGS, About the EROS Data Center, http://edc.usgs.gov/about/background.html.
[99] Land Processes Distributed Active Archive Center, http://lpdaac.usgs.gov/main.asp.
[100] UNEP/GRID, http://www.na.unep.net/des/deshome.php3.
[101] UN System-Wide Earthwatch, http://earthwatch.unep.net/index.php.
[102] UN System-Wide Earthwatch, Desertification and Drought, http://earthwatch.unep.net/desertification/index.php.
[103] UN System-Wide Earthwatch, Remote Sensing, http://earthwatch.unep.net/data/remotesens.php.

3.3.4 Opportunities and Recommendations to NASA for Further Involvement

NASA can play a role in monitoring the changes in land use in sensitive regions, as well as the transport of dust resulting from an increase in desertification. NASA could also play a strong role in disseminating technology and scientific and technical information, promoting access to appropriate monitoring technologies, and training scientists and decision makers in other countries in utilizing land use and air pollutant monitoring technologies. NASA could also benchmark the TESEO pilot project and experience of the ESA. Since much of the desertification issues deal with developing countries, particularly in Africa and Asia, NASA should coordinate with USAID (particularly with their Multilateral Policy and Conventions Team noted above). Additionally, NASA should coordinate with local NGOs and researchers in the regions who can best interpret land use and air issues in the region, by providing them with data and access.

From a technical perspective, much of the study of desertification is based on understanding of land use change. From an air quality perspective, tracking dust transported from desert regions can most effectively be done with satellite sensors. Specific NASA resources that should be explored for use in supporting desertification are:

- *Moderate Resolution Imaging Spectroradiometer (MODIS)*[104] on Terra and Aqua platform has existing aerosol products (MOD04 and MYD04) that could contribute to understanding of the transport of dust on a daily basis, particular for monitoring synoptic scale dust storms and transport over the ocean. MODIS products that measure vegetation, such as vegetation index (MOD13) and leaf area index (MOD15) could also be correlated with aerosols and their generation over time. Another role would be to use high-resolution *Landsat*[105] data in conjunction with MODIS vegetation data and aerosol optical depth data to understand the conditions that create dust both locally and in long-distance transport.

- *Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)*[106] on Terra platform offers high-resolution (15 to 90 square meters) data in 14 different wavelengths from visible to thermal infrared light. ASTER data could be used to create detailed maps of land surface temperature, emissivity, reflectance, and elevation, useful for understanding the land use conditions for desertification. Since it is co-located with the MODIS sensor on Terra, these two sensors could provide simultaneous land use, vegetation, and air quality information.

- NASA models such as *Land Information System (LIS)*[107] and *Land Data Assimilation Systems (LDAS)*[108] integrate a range of NASA resource inputs and could be applied to understand the hydrological cycle information that may contribute to desertification. While designed to contribute to weather models, their outputs appear relevant to

[104] http://modis-land.gsfc.nasa.gov/.
[105] http://landsat.gsfc.nasa.gov/.
[106] http://asterweb.jpl.nasa.gov/
[107] http://lis.gsfc.nasa.gov/.
[108] http://ldas.gsfc.nasa.gov/.

understanding the relationship between land use and dust storms although significant research would be required.

- NASA's *Land Cover Land Use Change (LCLUC)*[109] program, an interdisciplinary scientific theme within NASA's ESE, would be a key participant in any work focusing on desertification. They have conducted a number of studies on water and carbon cycles, human interaction with their environment, and change consequences and prediction, including related to desertification in key locations. Their land cover and land use monitoring knowledge could be combined with aerosol monitoring and modeling to increase understanding of the effect of land use on air quality, both locally and in long-distance transport.

3.4 Marine Ship Air Pollution and MARPOL

Most large commercial ships are powered by marine diesel engines that use fuels containing high concentrations of sulfur and other contaminants, and generate emissions from the combustion of these fuels. Air emissions from ships have attracted attention in recent years. As pollution from land-based sources of anthropogenic emissions in developed countries is generally decreasing, emissions from ships engaged in international marine trade are increasing. The major pollutants of concern include SO_x, NO_x, particulate matter, ozone depleting substances, and carbon dioxide. This section discusses the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto[110] (MARPOL 73/78). This section also discusses studies highlighting the importance of addressing ship air pollution, provides examples of the specific issues being addressed by ongoing research, and concludes with recommendations for NASA to become further engaged in this developing issue.

3.4.1 MARPOL 73/78

3.4.1.1 Structure and Organization

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978, respectively, and updated by amendments through the years. The Convention is commonly referred to as MARPOL 73/78 and includes six technical annexes; parties to the Convention (States) must accept Annexes I and II, but the other Annexes are voluntary. The U.S. has ratified all Annexes except Annexes IV and VI.[111] The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental and from routine operations. MARPOL 73/78 is being implemented in phases, with the air pollution Annex (VI) coming into force in 2005, and recent revisions (adopted in 2004) to other Annexes coming into force between 2005 and 2007.

[109] http://lcluc.gsfc.nasa.gov/.
[110] International Maritime Organization (IMO), http://www.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258, accessed 12/27/04.
[111] Annex VI was submitted to the U.S. Senate by President Bush on May 15, 2003, with a recommendation for ratification; the U.S. Senate has not yet ratified Annex VI.

SUMMARY

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

Location of Adoption:	London, England
Year of Adoption:	1973 and 1978
Overall Treaty Status:	Annexes I & II entered into force in 1983 Annex III entered into force in 1992 Annex IV entered into force in 2003 Annex V entered into force in 1988 Annex VI set to enter force in May 2005
Parties:	127 (Annexes 1 and 2) including U.S.
Status in U.S.:	In force (U.S. has ratified all Annexes except Annexes IV and VI)
U.S. Delegation Lead:	U.S. State Department, with U.S. EPA, Coast Guard, and others
Major Annexes:	
Annex I	Prevention of pollution by oil
Annex II	Control of pollution by noxious liquid substances
Annex III	Prevention of pollution by harmful substances in packaged form
Annex IV	Prevention of pollution by sewage from ships
Annex V	Prevention of pollution by garbage from ships
Annex VI	Prevention of Air Pollution from Ships

MARPOL 73/78 is one of more than 40 international conventions and agreements dealing with shipping that were established through the coordination of the International Maritime Organization (IMO). The IMO includes 164 Member States (countries), and is responsible for ensuring that existing conventions are kept up to date and new conventions are developed as needed. The IMO has six main bodies[112] concerned with the adoption or implementation of conventions. Developments in shipping and other related industries are discussed by Member States in these bodies. The role of the IMO in MARPOL 73/78 and other conventions is similar to that of a Secretariat, in that it facilitates cooperation and deals with administrative and legal matters.

Annex VI, Prevention of Air Pollution from Ships,[113] was adopted in September 1997 and is set to enter into force on May 19, 2005. Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs). Annex VI also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs). The regulations in this Annex, when they come into force in 2005, will also set limits on SO_x and NO_x emissions from ship exhaust. A mandatory NO_x Technical Code,[114] developed by IMO, defines how NO_x emissions are to be reduced from diesel engines, although one report[115] notes that the standards are set at such a high level that most new engines are already in compliance. In addition, the regulations include a global cap of 4.5% on the sulfur content of fuel oil and contain provisions allowing for special "SO_X Emission Control Areas" to be established with more stringent controls on sulfur emissions. In these areas, the sulfur content of fuel oil used on board ships must not exceed

[112] The Assembly and Council are the main organs, and the committees involved are the Maritime Safety Committee, Marine Environment Protection Committee, Legal Committee and the Facilitation Committee.
[113] MARPOL Annex VI, Prevention of Air Pollution from Ships, http://www.epa.gov/otaq/regs/nonroad/marine/ci/annex_vi.pdf.
[114] Conference Resolutions 1 to 8 and the NOx Technical Code adopted by the Conference, http://www.epa.gov/otaq/regs/nonroad/marine/ci/nox_cod.pdf.
[115] Air Pollution from ships; The European Environmental Bureau, The European Federation for Transport and Environment, Seas at Risk, The Swedish NGO Secretariat on Acid Rain, Updated November 2004.

1.5%. Alternatively, ships must fit an exhaust gas cleaning system or use any other technological method to limit SO_x emissions. The Baltic and North Seas have been designated as SO_x Emission Control Areas.

In addition to the specific requirements of Annex VI, Article 17 of MARPOL 73/78 requires the parties to promote, in consultation with other international bodies and with the assistance of UN Environment Program, support for those parties who request technical assistance for various purposes, such as training, the supply of equipment, research, and combating pollution.

3.4.1.2 Monitoring and Enforcement

The enforcement of IMO conventions generally depends upon the governments of Member Parties, which enforce the provisions of IMO conventions as far as their own ships are concerned and also set the penalties for infringements, where these are applicable. The governments may also have certain limited powers with respect to the ships of other governments. The IMO itself has no powers to enforce conventions.

MARPOL 73/78 states, "Parties to this Annex shall co-operate in the detection of violations and the enforcement of the provisions of the present this Annex, using all appropriate and practicable measures of detection and environmental monitoring, adequate procedures for reporting and accumulation of evidence" (Regulation 11). Each signatory nation is responsible for enacting domestic laws to implement MARPOL 73/78 and effectively pledges to comply with the convention, annexes, and related laws of other nations. When a ship visits another country's waters, the country that the ship visits can conduct its own examination to verify a ship's compliance with international standards and can detain the ship if it finds significant noncompliance."[116] With respect to enforcement penalties, MARPOL 73/78 states, "Any violation of the MARPOL 73/78 Convention within the jurisdiction of any Party to the Convention is punishable either under the law of that Party or under the law of the flag State."

3.4.1.3 Status in U.S.

In the U.S., the Act to Prevent Pollution from Ships (APPS)(33 USC §§1905-1915) implements the provisions of MARPOL 73/78 and the annexes which the United States has ratified (I, II, III, and V). A July 2004 Congressional Research Service (CRS) Report[117] notes that, "APPS applies to all U.S.-flagged ships anywhere in the world and to all foreign-flagged vessels operating in navigable waters of the United States or while at port under U.S. jurisdiction. The U.S. Coast Guard has primary responsibility to prescribe and enforce regulations necessary to implement APPS in these waters. The regulatory mechanism established in APPS to implement MARPOL is separate and distinct from the Clean Water Act and other federal environmental laws."

[116] Congressional Research Service, The Library of Congress, Cruise Ship Pollution: Background, Laws and Regulations, and Current Issues, July 2, 2004, Claudia Copeland, Specialist in Resources and Environmental Policy Resources, Science, and Industry Division, http://www.ncseonline.org/NLE/CRSreports/04Jul/RL32450.pdf.
[117] Ibid.

With respect to the air pollution Annex VI (which has not been ratified by the United States), the EPA unveiled a voluntary certification program[118] in 1999 for engine manufacturers to show that their engines are compliant with NO_x limits in Annex VI. This voluntary certification program was developed in anticipation of potential Annex VI ratification (by the United States) and entry into force, and also in anticipation of future EPA rules governing ship air pollution. Ship air emissions were first regulated in the United States in February 2003 when EPA promulgated emission standards for new marine diesel engines on large vessels such as container ships, tankers, bulk carriers, and cruise ships flagged or registered in the United States. Standards in the rule are equivalent to the NO_x standards in Annex VI, and EPA stated at the time that engine manufacturers already met those standards. Upon its release of marine diesel engine emission standards in February 2003, EPA announced that over the next two years it would continue to review issues and technology related to emissions from large marine vessel engines and would promulgate additional, more stringent emission standards (called Tier 2 standards) by April 2007. EPA noted that addressing long-term standards in a future rulemaking could facilitate international efforts through the IMO, while also permitting the United States to proceed, if international standards are not adopted in a timely manner.

Subsequently, as part of the May 2004 Clean Air Nonroad Diesel Rule,[119] EPA created new requirements for nonroad diesel fuel to decrease the allowable levels of sulfur in fuel used in marine vessels by 99 percent. EPA is also proposing stricter emission standards for all new commercial, recreational, and auxiliary marine diesel engines except the very large Category 3 engines used for propulsion on sea-going vessels, which are subject to separate regulations. The new standards could apply to designated marine engines by 2011. EPA estimates that full implementation of these two regulatory initiatives will result in particulate matter reductions of 95%, NO_x reductions of 90%, and the virtual elimination of SO_x from marine engines that meet the new standards.[120]

3.4.2 Relevant Studies and Ongoing Research

Several recent studies and reports have highlighted the importance of addressing ship air pollution. A U.S. Commission on Ocean Policy report[121] released in September 2004 notes that marine diesel engines have high emissions on a per engine basis and contribute to high ozone and particulate matter levels in many coastal and port areas. The report states that, "A study of global impacts from large vessel air emissions indicates that approximately 80 percent of vessel air emissions occur within 200 miles of the coast, and that a major part of these emissions are concentrated in a few areas in the Northern Hemisphere, primarily along the east and west coasts of the United States, in the North Pacific, and in northern Europe. International and domestic marine trade is predicted to more than double in the next twenty years, reinforcing the need to

[118] U.S. Environmental Protection Agency, Frequently Asked Questions, MARPOL 73/78 Annex VI Marine Diesel Engine Requirements, http://www.epa.gov/otaq/regs/nonroad/marine/ci/f99038.pdf; also see U.S. EPA Diesel Boats and Ships, Miscellaneous Documents, http://www.epa.gov/otaq/marine.htm#other.
[119] Clean Air Nonroad Diesel - Final Rule, http://www.epa.gov/nonroad-diesel/2004fr.htm.
[120] Congressional Research Service, The Library of Congress, Cruise Ship Pollution: Background, Laws and Regulations, and Current Issues, July 2, 2004, Claudia Copeland, Specialist in Resources and Environmental Policy Resources, Science, and Industry Division, http://www.ncseonline.org/NLE/CRSreports/04Jul/RL32450.pdf.
[121] An Ocean Blueprint for the 21st Century, Final Report of the U.S. Commission on Ocean Policy, http://www.oceancommission.gov/documents/prepub_report/welcome.html#full.

expeditiously develop and implement measures to abate vessel-generated air pollution." This report includes a recommendation for U.S. ratification of Annex VI.

A recent European study concluded that ship emissions are estimated to contribute between 20 and 30% of the ambient concentrations of secondary inorganic particles in most European coastal areas. Even accounting for enforcement of MARPOL 73/78 Annex VI, by 2020 emissions from international shipping around Europe will have surpassed the total from all land-based sources in the 25 IMO Member States combined. A July 2004 Congressional Research Service Report[122] on cruise ship pollution identifies several areas of research to help improve understanding of the impacts of discharges and emissions and the potential for new control technologies. Specifically, the report recommends research on the impacts of vessel air emissions, particularly in ports and inland waterways where the surrounding air does not meet air quality standards.

One recent study[123] in which NASA was involved presented the first detection of ship tracks in NO_2 maps derived from satellite data. The study examined the congested shipping track connecting Sri Lanka to Indonesia and estimated the corresponding ship emissions of NO_x. The NASA Goddard Space Flight Center was involved in this study (through one of the study authors, Dr. Mark Wenig). The study used the 6-year composite of cloud free Global Ozone Monitoring Experiment (GOME) observations. In their conclusions, the authors note, "Successors of GOME like the SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY), the Ozone Monitoring Instrument (OMI) and GOME II with improved spatial resolution might even allow the detection of further ship tracks." Another recent study[124] conducted at the University of Delaware Marine Policy Program presents a model to estimate and geographically represent offshore vessel traffic and air emissions based on actual shipping activities. This study focuses on designating SO_X Emission Control Areas, under MARPOL 73/78 Annex VI.

For non-air quality Annexes, one example of ongoing application of Earth observation systems and associated data and information is oil pollution monitoring of the seas using synthetic aperture radar to support this Convention.[125]

3.4.3 Opportunities and Recommendations to NASA for Further Involvement

The use of remote sensing for monitoring ship air emissions at sea is beneficial since monitoring emissions from multiple moving sources off-shore, many of which are not flagged as U.S. ships, is difficult using a sparse network of ground-based or ocean-based monitors.

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[122] Congressional Research Service, The Library of Congress, Cruise Ship Pollution: Background, Laws and Regulations, and Current Issues, July 2, 2004, Claudia Copeland, Specialist in Resources and Environmental Policy Resources, Science, and Industry Division, http://www.ncseonline.org/NLE/CRSreports/04Jul/RL32450.pdf.
[123] S. Beirle, U. Platt, R. von Glasow, M. Wenig, and T. Wagner, Estimate of nitrogen oxide emissions from shipping by satellite remote sensing, Geophysical Research Letters 31, L18102, doi:10.1029/2004GL020312, 2004.
[124] Wang, Chengfeng and Corbett, James, Geographical Characterization of Ship Traffic and Emissions, University of Delaware Marine Policy Program, Submitted for publication, October 25, 2004.
[125] American Institute of Aeronautics and Astronautics, International Activities Committee, 6th International Space Cooperating Workshop Report, March 2001, http://sedac.ciesin.columbia.edu/rs-treaties/AIAA6thWorkshop.pdf, accessed 7/20/04.

However, current spatial and temporal resolutions and the range of chemical species that can be monitored remotely significantly limits this application. Spatial resolutions must be fine enough to detect ship tracks; alternatively, for areas where the major shipping lanes are known, an integrated model of satellite data and geospatial data could be developed. A significant challenge is distinguishing ship emissions from emissions generated on land and blown off-shore.

As noted, the United States has not ratified MARPOL 73/78 Annex VI, related to air quality. Although EPA has begun to address ship air emissions in the regulatory context, it appears that future rulemakings and/or treaty ratification and legislative action must occur before NASA Earth science data could play a monitoring and enforcement role. Therefore, NASA's role in the near term could be to assist in understanding the general air pollutant emission levels from ships and it is recommended that significant further action by NASA be deferred. Despite these limitations, ship emissions are a growing concern, and these challenges may represent a new research area where NASA can contribute significantly. Potential existing NASA resources include:

- *Measurements of Pollution in the Troposphere (MOPITT)*[126] carbon monoxide product (MOP02) is fairly spatially coarse, but could be investigated to identify combustion emissions along major shipping routes. Similarly, visible images from *Moderate Resolution Imaging Spectroradiometer (MODIS)*[127] on Terra and Aqua could contribute to understanding emissions.

- The *Ozone Monitoring Instrument (OMI)*[128] and *Tropospheric Emission Sounder (TES)*,[129] both on the Aura platform, have products in development that may provide useful information, particularly on ozone, NO_2, and SO_2. Again, coarse spatial resolution will require study of major shipping lanes.

- It is unclear if atmospheric models from NASA, such as *Regional Air Quality Modeling System (RAQMS)*[130] for ozone and *Goddard Chemistry Aerosol Radiation and Transport (GOCART)*[131] for aerosols could also be applied toward increasing understanding of ship emissions. However, they could form the foundation of modeling mobile sources.

[126] http://terra.nasa.gov/About/MOPITT/.
[127] http://modis-atmos.gsfc.nasa.gov/.
[128] http://aura.gsfc.nasa.gov/instruments/omi/introduction.html.
[129] http://aura.gsfc.nasa.gov/instruments/tes/introduction.html.
[130] http://asd-www.larc.nasa.gov/new_AtSC/raqms.html.
[131] http://code916.gsfc.nasa.gov/People/Chin/gocartinfo.html.

4.0 BROADER DISCUSSION OF NASA INVOLVEMENT IN INTERNATIONAL POLICY

NASA Earth science has unique capabilities and resources to monitor the Earth's environment, including air quality. Satellite sensors have already played a key role in documenting the intercontinental transport of air pollutants and enhancing understanding of pollutants crossing international boundaries. As a research agency, NASA is primarily focused on scientific and academic studies, such as measurement campaigns, that increase understanding of global issues and provide validation for sensors and models. NASA has also successfully promoted many of its resources to the public and provided its datasets for use by other agencies, such as EPA. With its suite of polar-orbiting satellites, the Earth Observing System, and global modeling capability, NASA has much to offer the international community for monitoring and developing international environmental policy.

However, serious contribution to international policy requires on-going relationships with the appropriate U.S. agencies and, through them, with the Secretariats and working groups that are established to create and implement international agreements. While ad hoc projects may be effective for demonstrations and research, and may contribute to scientific understanding, they will not further the use of NASA resources into international environmental policy. Policymakers need on-going value-added products from trusted sources of information that are designed to meet their decision needs.

Thus, it is important for NASA to determine its level of commitment to participation in the international policy process. The funding commitment may not need to be large, but would benefit from the establishment of a specific program that understands the international policy process and can offer resources toward international collaboration, funding of work groups, and support for user groups to develop the products needed by decision makers. One approach would be to follow the ESA GSE program model by funding user work groups in key areas. Users would include the policy community as well as private and public data providers. The process would focus on specific subject areas and encourage two-way feedback.

Another approach is to use air quality as an initial project area, similar to ESA's TESEO pilot projects. At least two major international treaties (LRTAP and the U.S.-Canada Bilateral Agreement) are at stages where involvement from a new organization with unique resources may be welcome. NASA has good relations with EPA employees involved in these treaties. An area such as desertification builds on two existing NASA programs (land use and atmospheric science) and would involve collaboration with USAID. Ship emissions represent a new area of research, already involving limited NASA resources. Lessons learned from these initial air quality projects could be used to establish a program or process that would expand involvement into other areas, both for air quality and other media (water, land, etc.).

Overall, given NASA's global view of the Earth and the increasing importance of an international approach to environmental policy, NASA could bring considerable value to both U.S. agencies involved in international policy as well as scientists in developing countries that may lack monitoring resources for developing local environmental policy. The key is for NASA to develop a process to provide data and/or value-added information to policymakers and to

receive their input on new products and sensors. This does not have to be developed in-house, but could be accomplished with a core group within the NASA Applications team focused on developing the partnerships (private and public) that will facilitate international policy collaboration for NASA. The initial air quality projects described within this report demonstrate the importance of identifying the end users of the data, ascertaining their needs, and responding to end users through the design and operating parameters of current and future Earth observation programs to facilitate their successful application to international policy instruments.

Based on the considerations discussed above, the report authors recommend the following actions for NASA to increase its involvement in supporting international policy:

- *Clarify NASA interest and role in international policy process.* NASA should determine whether it is interested in supporting U.S. delegations in the international policy process, and if so, the role NASA can play. By starting with a few key initial projects focused on air quality, based on the recommendations in this paper, NASA can learn the international policy process and better understand how it can best support these types of policies.

- *Determine focus areas*. While a wide range of subject areas could be considered, NASA should focus on upcoming issues where it can provide unique resources. Transport of air pollutants and land use would be logical initial choices.

- *Consider formalizing international policy expertise.* Formalizing NASA's international treaty expertise would indicate long-term interest in involvement and reduce dependency on the interest in international issues of subject matter experts. Applications are currently organized by subject area, but one or more international policy expert(s) could coordinate with Applications staff and subject area scientists to work with policymakers and end users. Such an expert or experts could be located within the Cross-Cutting Team of the Applied Sciences Program. Alternatively, the international activities group within the Science Division of the Office of External Relations could be expanded to include staff with international policy expertise. Because the coordination on international policy instruments would primarily be with other U.S. agencies that are part of the U.S. delegation, rather than with agencies in other countries, the most logical location for international policy expertise may be the Cross-Cutting Team.

- *Develop relationship with international sections of U.S. agencies to collaboratively determine needs and provide information*. All international policy support conducted by NASA should be done in close collaboration with the lead U.S. agency for that policy. These relationships need to be developed and maintained over time, since most international policy instruments take years to develop and are in place for decades. Many policy experts are unaware of the capabilities of NASA resources. Long-term relationships allow for two-way feedback, where NASA provides valuable information to the agencies involved and can also receive input on its products and sensors.

- *Determine mechanism to provide value-added information, such as data user work groups by subject area*. NASA products currently focus on the research community and,

to a limited extent, the general public. A mechanism needs to be developed to support the policy community, especially due to the long-term nature of international policy. This function is currently partially addressed through the Federation of Earth Science Information Partners[132] (ESIP), which brings together government agencies, universities, non-profit organizations, and businesses in an effort to make Earth Science information available to a broader community. NASA is the founder and sponsoring agency of ESIP. In coordination with its current ESIP activities, one approach is for NASA to retain its scientific focus and to establish (and fund) end user work groups by specific policy subject area. This may be done by establishing an international policy group within ESIP, or through another mechanism designed to support the policy community. The end users would be responsible for working with NASA data and researchers, and converting the data into value-added information. The range of end users to be considered could include:

- International decision-making bodies such as: the UN General Assembly; the Commission on Sustainable Development; the conferences of parties; and Secretariats to international and regional conventions.
- National governments and their relevant ministries, including scientists on staff, mid-level policymakers, and senior decisionmakers.
- The scientific community, international research programs, and international scientific advisory processes.
- The private sector, including data processors and information providers.
- Non-governmental and public service organizations.

[132]Federation of Earth Science Information Partners, http://www.esipfed.org.

5.0 CONCLUSION AND GENERAL RECOMMENDATIONS

This report examines selected international air quality policy instruments with the greatest potential for application of NASA Earth science research and makes technical recommendations to NASA for further involvement in each of these policy instruments. The report also addresses the broader framework needed for NASA to increase its involvement in international policy. Based on these technical and policy recommendations, the following near- and long-term actions are recommended to move NASA from concept to action on international air quality policy instruments.

In the near term, NASA should:

- Contact EPA about supporting the LRTAP workgroup studying hemispheric issues and participating by providing data and modeling analysis that fits the workgroup's needs (see specific EPA contacts in LRTAP section).

- Contact EPA about supporting the bilateral Air Quality Committee study of a potential PM Annex, specifically monitoring, quantifying, and modeling cross-border transport (see specific EPA contacts in U.S.-Canada Bilateral Air Quality Executive Agreement section).

Of less direct applicability to air quality and NASA resources, NASA could:

- Coordinate with NASA's Land Cover Land Use Change (LCLUC) program to determine possible interest and studies on air quality related to desertification. With LCLUC and NASA atmospheric experts, consider contacting USAID about possible interest in project collaboration.

- Consider convening a discussion of remote sensing of ship emissions with EPA, Coast Guard, and academics, to determine needs and potential for research efforts that support MARPOL Annex VI.

In addition to following up on the above near-term actions, in the long term NASA should examine its overall approach to involvement in international policy. Specifically, by identifying lessons learned from the initial air quality projects that evolve from the agency coordination recommended above, NASA should establish in-house cross-cutting international policy expertise and begin a process that would expand involvement into other policy areas (including other air quality issues, and other environmental media such as water and land use). In this process, NASA should capitalize on its existing involvement in international organizations such as CEOS and IGOS, involve the global systems of GEO, and consider the experience of ESA in pursuing policy support applications.

Ultimately, NASA will need to determine if there is Agency commitment to continue involvement beyond an ad hoc process such as targeted individual projects. If so, NASA should consider its structure to provide data and value-added products to policymakers and to receive

their input on new products and sensors. Because this level of applications may not be fully developed in house, NASA may need to develop partnerships (both private and public) that will facilitate international policy applications.

APPENDIX A:

BACKGROUND AND TERMINOLOGY OF INTERNATIONAL ENVIRONMENTAL LAW

This appendix explains the background and terminology of international environmental law, including the role of the United Nations (UN), legal terminology, international treaty management and monitoring, and a glossary of key terminology.

Background of International Environmental Law

The environment has risen rapidly in prominence as a public issue over the last several decades. Several major UN conferences are important landmarks in the increasing global focus on environmental issues: the Conference on Human Environment held in Stockholm in June 1972, the Conference on Environment and Development held in Rio de Janeiro in June 1992, and the World Summit on Sustainable Development held in Johannesburg in 2002.

The Stockholm conference of 1972 was the beginning of an era of major UN theme conferences, convened to focus worldwide attention on specific, broadly defined problems and set forth principles and propose action plans for addressing them. Most theme conferences adopt two types of nonbinding documents: declarations laying out the guiding principles for efforts to address a given problem, and a plan of action describing specific steps. Some action plans call for the establishment of new international institutions and the creation of special funds targeted at the needs of developing countries. For example, based on a recommendation of the Stockholm conference, the UN General Assembly established the UN Environment Program (UNEP) to stimulate, coordinate, and facilitate environmental efforts by national governments and other international organizations, including the UN specialized agencies. In addition to collecting and disseminating information about the environment, UNEP has been involved in creating and implementing major international environmental agreements and programs.

UNEP has established partnerships with other international agencies and non-governmental organizations (NGOs), such as the International Council of Scientific Unions, the World Conservation Union, and the World Wildlife Fund. In addition, many regional and bilateral organizations address environmental problems. For example, the International Joint Commission, set up by Canada and the United States in 1909, deals with threats to the boundary waters between the two countries. The UN Economic Commission for Europe (ECE) has overseen efforts to limit emissions of air pollutants.

There are several intrinsic limitations to the effectiveness of international environmental agreements. Treaties bind only those States that voluntarily agree to comply with them. Thus, the agreements sometimes represent the "lowest-common denominator," designed to maximize the number of States willing to become parties. Also, because international enforcement mechanisms are generally weak, if they exist at all (as discussed further below), compliance with treaty obligations depends largely on the good faith of States being regulated. Finally, most international environmental agreements are responses to specific environmental problems, and do no constitute a comprehensive or integrated body of international environmental law.[133]

[133] Kraft, Michael E. and Vig, Norman J. Vig, Environmental Policy in the 1990s, Third Edition, Part IV: Toward Global Environmental Policies, Congressional Quarterly Inc. 1997.

International Treaty Legal Terminology

In international law, **treaties** can be referred to by a number of different names: international conventions, international agreements, covenants, final acts, charters, protocols, pacts, accords, and constitutions for international organizations. Usually these names have no legal significance in international law. In practice, a **convention** is often the first treaty that is established on a particular issue, providing the framework for addressing the issue, and is normally open for participation by the international community as a whole, or by a large number of States. Additional **agreements** (either **amendments** or **additions**) related to the convention are often called **protocols** or **annexes**.

Treaties may be **bilateral** (two parties) or **multilateral** (between several parties), and a treaty is usually only binding on the parties to the agreement (those nations that sign and, in the case of multilateral agreements, ratify the agreement). An agreement "**enters into force**" when the terms for entry into force as specified in the agreement are met. For multilateral agreements, terms for entry into force often include a requirement that a certain number or group of signatories to the treaty actually ratify the treaty through their own ratification process. Bilateral treaties usually enter into force when both parties agree to be bound as of a certain date.[134]

No precise nomenclature exists for international law. In fact, the meaning of the terms used is variable, changing from State to State, from region to region, and from instrument to instrument. Some of the terms can easily be interchanged: an instrument that is designated "agreement" might also be called "treaty." In U.S. domestic law, however, the terms "treaty" and "executive agreement" have specific meanings beyond those of international law. The word **treaty** is reserved for an agreement that is made "by and with the Advice and Consent of the Senate" (Article II, section 2, clause 2 of the Constitution). International agreements not submitted to the Senate are known as **executive agreements** in the United States. Executive agreements in the U.S. are reached through an interagency approval process. Regardless of whether an international agreement is called a convention, agreement, protocol, accord, etc., if it is submitted to the Senate for advice and consent, it is considered a treaty under U.S. law.

For clarity in this report, each convention, protocol, agreement, or treaty is identified with the terminology by which it is known in international law, and the more general term "policy instrument" is used to refer to any individual convention/ protocol/agreement/treaty/etc. Note that in the glossary below, "State" refers to a nation rather than a U.S. state.

International Treaty Management and Monitoring

Many international policy instruments create an institution, often called a **Secretariat**, to administer the agreement. Under some agreements these institutions are independent entities; under other agreements the institutions are UN entities. Secretariats are responsible for such

[134] Marci Hoffman, Researching U.S. Treaties and Agreements, http://www.llrx.com/features/ustreaty.htm#U.S., accessed 7/24/04.

tasks as compiling reports based on submissions from the parties, administering requests for technical assistance, and arranging the logistics for meetings of the parties[135].

The requirements and monitoring of international policy instruments are unique to each instrument and vary widely. International policy instruments are often intended to accomplish broad goals but do not always provide that the parties must achieve specific objectives within certain time frames. Other agreements spell out specific objectives and reporting requirements, but may or may not include mechanisms for monitoring whether the parties are fulfilling their commitments or for enforcing compliance. There are generally few penalties for a nation's failure to fulfill a commitment, or where there is a penalty, the mechanisms to enforce compliance are rarely used.

In the United States, the Department of State is generally the U.S. representative for negotiations or meetings related to international treaties, unless the Department of State has delegated lead on a particular treaty to another U.S. agency, such as U.S. EPA. The Department of State and other agencies generally use informal means to track U.S. actions to fulfill its commitments under international policy instruments[136]. A 2002 self-audit on five international policy instruments (to which the United States is a Party) conducted by the U.S. General Accounting Office for Congressional testimony noted that, from 1997 to 2002, the United States agreed to submit 21 reports on implementation and related issues. The United States eventually submitted each report though not always by the specified deadline.

Glossary of Terms[137]

Agreement: The term "international agreement" in its generic sense consequently embraces the widest range of international instruments. In international law, "agreements" are usually less formal and deal with a narrower range of subject-matter than "treaties." There is a general tendency to apply the term "agreement" to bilateral or restricted multilateral treaties. It is employed especially for instruments of a technical or administrative character, which are signed by the representatives of government departments, but are not subject to ratification. In U.S. domestic law, "executive agreement" refers to agreements that are not made "by and with the Advice and Consent of the Senate" (Article II, section 2, clause 2 of the Constitution) (see "Treaty").

Annex: An amendment or addition to a treaty or agreement.

Convention: The term generally used for formal multilateral treaties with a broad number of parties. Conventions are normally open for participation by the international community as a whole or by a large number of States. Usually the instruments negotiated under the auspices of

[135]Testimony Before the Committee on Environment and Public Works and the Committee on Foreign Relations, U.S. Senate, United States General Accounting Office, July 24, 2002, International Environment: U.S. Actions to Fulfill Commitments Under Five Key Agreements, Statement for the Record by John B. Stephenson, Director, Natural Resources and Environment, http://www.gao.gov/new.items/d02960t.pdf.

[136] Ibid.

[137] United Nations Treaty Collection Treaty Reference Guide, http://untreaty.un.org/English/guide.asp#agreements, accessed 7/24/04, Environmental Treaties and Resource Indicators, Section 2: Environmental Treaties and Other Policy Instruments, http://sedac.ciesin.columbia.edu/entri-old/guides/sec2.html, accessed 7/24/04.

an international organization are entitled conventions (e.g., Convention on Biological Diversity of 1992, United Nations Convention on the Law of the Sea of 1982, Vienna Convention on the Law of Treaties of 1969). In practice, a convention is often the first treaty that is established on a particular issue providing the framework for addressing the issue.

Date of adoption: Date when States participating in the negotiation of a treaty agree on its final form and content. This usually occurs before signature.

Date of signature: Date when a State signs a treaty, usually at a meeting or convention where the treaty was drafted. For treaties where the signature is subject to ratification, acceptance, or approval, the signature does not establish the consent to be bound. However, it is a means of authentication and expresses the willingness of the signatory State to continue the treaty-making process. For treaties where the signature is not subject to ratification, acceptance or approval, the signature does in fact establish the consent to be bound.

Entry into Force: Date when a treaty becomes binding upon the States that have expressed their willingness to be bound by it. This is usually triggered by a clause in the text of the treaty saying something like "this treaty shall enter into force when # States have signed it ..." Where the treaty does not specify a date, there is a presumption that the treaty is intended to come into force as soon as all the negotiating States have consented to be bound by the treaty. Bilateral treaties may provide for their entry into force on a particular date, upon the day of their last signature, upon exchange of the instruments of ratification, or upon the exchange of notifications. In cases where multilateral treaties are involved, it is common to provide for a fixed number of States to express their consent for entry into force. A treaty enters into force for those States that gave the required consent.

Party to a Treaty: A State that has consented to be bound by a treaty (through signature and ratification, as required by the treaty) and for which the treaty is in force.

Policy Instrument: General term is in this document to refer to any individual convention/protocol/agreement/treaty/etc.

Protocol: An amendment or addition to a treaty or agreement.

Ratification: The process whereby a national government establishes its consent to be bound by a treaty. This can take place upon signature or at a later date, but usually occurs after signature. Different nations have different methods of ratification. In the United States, ratification requires submittal to the U.S. Senate and a favorable vote of two-thirds of the U.S. Senate. The institution of ratification grants States the necessary time-frame to seek the required approval for the treaty on the domestic level and to enact the necessary legislation to give domestic effect to that treaty.

Secretariat: An administrative unit responsible for maintaining records and other secretarial duties; especially for international organizations.

Signatory to a Treaty: A State that signs a treaty (refer to Date of signature). A signatory to a treaty is not bound to consent to a treaty unless the specific treaty does not require ratification. Most bilateral treaties dealing with more routine and less politicized matters are brought into force by definitive signature, without recourse to the procedure of ratification.

Treaty: In international law, the term "treaty" has regularly been used as a generic term embracing all binding international law instruments established between international entities, regardless of the formal designation of the international law instruments. In U.S. domestic law, however, the term "treaty" is reserved for an agreement that is made "by and with the Advice and Consent of the Senate" (Article II, section 2, clause 2 of the Constitution).

APPENDIX B:

MULTILATERAL AIR QUALITY POLICY INSTRUMENTS

This appendix provides basic information on each of the major multilateral air quality policy instruments, organized according to the following table.

Topic	*Policy Instrument**
Climate Change	**United Nations Framework Convention on Climate Change, New York, 1992**
	Kyoto Protocol, 1997
Transboundary Pollution: Global	**Convention on Long-Range Transboundary Air Pollution, Geneva, 1979**
	Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes, Sofia, 1988
	Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes, Sofia, 1991
	Protocol on Persistent Organic Pollutants, Aarhus, 1998
	Protocol to the Convention on Long-Range Transboundary Air Pollution on Heavy Metals, Aarhus, 1998
	Gothenburg Protocol to Abate Acidification, Eutrophication, and Ground-level Ozone, 1999
	Convention on Environmental Impact Assessment in a Transboundary Context, Espoo, 1991
Transboundary Pollution: Canada & Mexico	**Agreement on Great Lakes Water Quality, Ottawa, 1978**
	Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area, La Paz, 1984
	North American Agreement on Environmental Cooperation, Washington DC, Mexico, and Canada, 1993
	U.S.-Canada Bilateral Air Quality Executive Agreement (Including Annexes 1 and 2), Ottawa, 1991
	Annex 3, the Ozone Annex, Ottawa, 2000
Stratoshperic Ozone Depletion	**Convention for the Protection of the Ozone Layer, Vienna 1985**
	Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
	Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, London, 1990
	Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, Copenhagen, 1992
POPs	**Stockholm Convention on Persistent Organic Pollutants, 2001**
Land Use	**Convention to Combat Desertification Particularly in Africa, Paris, 1994**
Other	**International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)**
	World Health Organization Air Quality Guidelines

*Initial conventions and treaties are listed in **bold** type, followed by any associated protocols or annexes, which are listed in regular (not bold) type.

B1.0 CLIMATE CHANGE

CLIMATE CHANGE	
Title: United Nations Framework Convention on Climate Change	
Location of Adoption: New York, U.S.	**Year of Adoption:** 1992
Overall Status: Entered into force in 1994	
Status in U.S.: Ratified in 1992 **U.S. Delegation:** Led by State Department. Also includes involvement by the National Oceanic and Atmospheric Administration (NOAA)[138] and Environmental Protection Agency (EPA).	
Parties that have Signed and Ratified the Convention: 189, including the U.S.	
Summary of Purpose: The ultimate objective of the Convention is "to achieve…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-induced] interference with the climate system." The Convention's objective further provides that "Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"(Article 2). **Methods to Accomplish Purpose:** Calls upon developed countries (Annex I countries, including the United States) to "aim" at returning their emissions of greenhouse gases to 1990 levels by 2000 and to submit periodic reports describing the steps that are being taken to achieve this goal. Also calls upon Annex II countries (Organization for Economic Cooperation and Development members that do not qualify as economies in transition) to help finance certain Convention-related projects and to promote and finance the transfer of, or access to, environmentally sound technologies, particularly for developing country Parties. [139] The Convention lays out various requirements for Parties to mitigate climate change and potential impacts. For example, the Convention requires that Parties "Promote and cooperate in research, systematic observation and the development of data archives related to the climate system so as to further understanding and reduce uncertainties about the causes, effects, magnitude and timing of climate change and the consequences of response strategies" and "Promote and cooperate in the full, open and prompt exchange of scientific and other information related to the climate system and the consequences of response strategies" (Article 10). Specific means to reduce emissions were set in the Kyoto Protocol. The Convention also establishes two subsidiary bodies. The Subsidiary Body for Scientific and Technological Advice provides the Conference of Parties with timely information and advice on scientific and technological matters relating to the Convention. The Subsidiary Body for Implementation helps with the assessment and review of the Convention's implementation. **Current Status/Relevant Issues:** Activity is focused on the Kyoto Protocol to this Convention. Refer to Kyoto Protocol summary.	

[138] Ninth Conference of the Parties to the UN Framework Convention on Climate Change (COP-9), Dr. Harlan Watson, Head of U.S. Delegation and Senior Climate Negotiator and Special Representative; Vice Admiral Conrad Lautenbacher, Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, Press Briefing, Milan Italy, December 1, 2003, http://www.state.gov/g/oes/rls/rm/2003/26749.htm.
[139] U.S. Department of State, Implementation of Environmental Treaties, http://www.state.gov/g/oes/rls/rm/2002/12157.htm, accessed 7/20/04.

Potential application of NASA Earth science research:
High. NASA data and models are already extensively used to study global climate change and monitor carbon dioxide (CO_2) levels. Refer to the Kyoto Protocol to this Convention for specific implementation details and potential NASA Earth science research applications, particularly as related to carbon sequestration and monitoring.

CLIMATE CHANGE	
Title: Kyoto Protocol to the United Nations Framework Convention on Climate Change	
Location of Adoption: Kyoto, Japan	**Year of Adoption:** 1997
Overall Treaty Status: Entry into force on February 16, 2005[140] **Criteria Required for Entry into Force:** At least 55 Parties to the Convention needed to ratify (or approve, accept, or accede to) the Protocol, including enough Annex I Parties to encompass 55% of that group's CO_2 emissions in 1990. After Russia's ratification in December 2004, 61.6% of Annex I Parties CO_2 emissions in 1990 were included, trigerring the clock for entry into force.	
Treaty Status in U.S.: Signed in 1998, Not ratified (Bush administration withdrew the U.S. signature from the Protocol) **U.S. Delegation:** Led by State Department, also includes NOAA[141] and EPA	
Parties that have Signed and Ratified the Treaty: 132 (not the U.S.)	
Summary of Purpose: The Kyoto Protocol to the United Nations Framework Convention on Climate Convention is founded on the same principles as the Convention and shares its ultimate objective, as well as the way it groups countries into Annex I, Annex II, and non-Annex I Parties. The Kyoto Protocol establishes legally binding greenhouse gas emissions targets for industrialized countries. **Methods to Accomplish Purpose:** Requires industrialized (Annex I) countries to reduce their greenhouse gas emissions of six major greenhouse gases during the five-year period 2008-2012 to below 1990 levels. Creates innovative mechanisms by which emissions allocations can be traded among States. Requires the establishment of national systems for estimating anthropogenic emissions and sinks of greenhouse gases. Also allows parties to meet their emissions targets by sequestering carbon (carbon sinks) and establishes the Clean Development Mechanism that permits Annex I parties to invest in afforestation and reforestation projects in non-Annex I (developing) countries. Japan is slated for greenhouse gas cutbacks of 6% (from 1990 levels), while most European countries, including the 15 members of the European Union, agreed to reduce their emissions by 8% (from 1990 levels). Developing countries, including Brazil, China, India and Indonesia, are also Parties to the Protocol but do not have emission reduction targets. The Protocol also contains a set of general commitments (mirroring those in the Convention) such as taking steps to improve the quality of emissions data; mounting national mitigation and adaptation programs; promoting environmentally friendly technology transfer; cooperating in scientific research and international climate observation networks; and supporting education, training, public awareness and capacity-building initiatives.	

[140] United Nations, Framework Convention on Climate Change Secretariat, Press Release, Kyoto Protocol to Enter into Force 16 February 2005, dated November 18, 2004, http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/press041118_eng.pdf.
[141] Ninth Conference of the Parties to the UN Framework Convention on Climate Change (COP-9), Dr. Harlan Watson, Head of U.S. Delegation and Senior Climate Negotiator and Special Representative; Vice Admiral Conrad Lautenbacher, Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, Press Briefing, Milan Italy, December 1, 2003 http://www.state.gov/g/oes/rls/rm/2003/26749.htm, accessed 7/21/04.

Current Status/Relevant Issues:

The Kyoto Protocol will enter into force on February 16, 2005, after which:

1) Thirty industrialized countries will be legally bound to meet quantitative targets for reducing or limiting their greenhouse gas emissions.

2) The international carbon trading market will become a legal and practical reality. The Protocol's "emissions trading" regime enables industrialized countries to buy and sell emissions credits amongst themselves; this market-based approach will improve the efficiency and cost-effectiveness of emissions cuts.

3) The Clean Development Mechanism (CDM) will move from an early implementation phase to full operations. The CDM will encourage investments in developing-country projects that limit emissions while promoting sustainable development.

4) The Protocol's Adaptation Fund, established in 2001, will start preparing itself for assisting developing countries to cope with the negative effects of climate change.

Potential application of NASA Earth science research:

High. In addition to ongoing NASA monitoring and modeling research on climate change, satellite data could be used to determine carbon sequestration potential for a given land area and to verify carbon sequestration activities, such as preservation of a forest in a given tract of land. Satellite data could also be used to identify existing greenhouse gas sources and sinks on a national level as part of the development of a national system for estimating anthropogenic emissions and sinks of greenhouse gases. There is a need for a number of greenhouse gas measurements that can be obtained wholly or partly via remote sensing, including methane and oxides of nitrogen (NO_X) emissions, which are related to land cover features, such as inundated areas, soil moisture, and temperature. There is an interest in land cover type, height, and above ground biomass (woody vegetation). Existing remote sensing technology may be more readily used for estimating carbon sequestration on agricultural lands than in forested areas because tillage practices and crop types can be identified through optical imagery alone.[142] Monitoring and modeling emissions using remote sensing data would be useful on a regional scale; when combined with sequestration, a country-level carbon budget could be an interesting and useful product.

[142] Alex de Sherbinin and Chandra Giri1, Center for International Earth Science Information Network, Remote Sensing in Support of Multilateral Environmental Agreements, Columbia University, http://sedac.ciesin.columbia.edu/rs-treaties/adesherbinin_riopaper.pdf, accessed 7/24/04.

B2.0 TRANSBOUNDARY POLLUTION

B2.1 Global

B2.1.1 Convention on Long-Range Transboundary Air Pollution and Associated Protocols[143]

TRANSBOUNDARY POLLUTION	
Title: Convention on Long-Range Transboundary Air Pollution[144]	
Location of Adoption: Geneva, Switzerland	**Year of Adoption:** 1979
Overall Treaty Status: Entered into force in 1983	
Treaty Status in U.S.: Signed in 1979, Ratified in 1981 **U.S. Delegation:** State Department Lead	
Parties that have Signed and Ratified the Treaty: 49 including the U.S.	
Summary of Purpose: To address transboundary air pollution. Although the Convention has evolved to handle issues like transboundary flows of Persistent Organic Pollutants and Heavy Metals (see Protocols that follow), it was originally conceived as a mechanism to deal with and manage "regional" transboundary air pollutants like sulfur, NO_x, and volatile organic compounds (VOCs), and air issues like acid rain and ground-level ozone.[145] The Convention was unique for its time because it recognized the principle that one State should not damage another with its air pollution. The origin of this Convention began when scientists demonstrated the interrelationship between sulfur emissions in continental Europe and the acidification of Scandinavian lakes. The 1972 United Nations Conference on the Human Environment in Stockholm signaled the start for active international cooperation to combat acidification. Between 1972 and 1977, several studies confirmed the hypothesis that air pollutants could travel several thousands of kilometers before deposition and damage occurred. This also implied that cooperation at the international level was necessary to solve problems such as acidification. **Methods to Accomplish Purpose:** Calls upon parties to limit or reduce transboundary air pollution using the "best available technology that is economically feasible" without establishing any specific emissions reductions. Besides laying down the general principles of international cooperation for air pollution abatement, the Convention sets up an institutional framework bringing together research and policy, which currently includes a Task Force on Measurements and Modeling.[146] **Current Status/Relevant Issues:** The Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) was initiated in 1977 as a special program under the United Nations Economic Commission for Europe. EMEP includes a Task Force on Measurement and	

[143] In addition to the Protocols described here, there are two to which the United States is not a Party: (1) Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution On the Reduction of Sulphur Emissions or Their Transboundary Fluxes By At least 30 Percent, Helsinki, 1985; and (2) Protocol to the Convention on Long-Range Transboundary Air Pollution On the Further Reduction of Sulphur Emissions, Oslo, 1994.

[144] Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe, http://www.unece.org/env/lrtap/, accessed 8/23/04.

[145] International Conventions/Protocols - Their Requirements for Ecological Monitoring, The Ecological Monitoring and Assessment Network, Third National Science Meeting, January 21-25, 1997, Saskatoon, Saskatchewan, http://www.eman-rese.ca/eman/reports/publications/nm97_abstracts/part-15.htm, accessed 8/23/04.

[146] Weuster, Henning, Progress Under the Convention for Long-range Transboundary Air Pollution, Introductory Presentation for the 4th Meeting of the Task Force on Measuring and Modeling, http://www.nilu.no/projects/ccc/tfmm/valencia/presentations/secreatriat_TFMM4.ppt#1, accessed 7/23/04.

Modeling. Active Working Groups are also addressing a range of issues. A Working Group on Effects provides information on the degree and geographic extent of the impacts of major air pollutants on human health and the environment. Under this working group, there are International Cooperative Programme groups on modeling and mapping and on integrated monitoring for the Convention and its protocols.[147]

Potential application of NASA Earth science research:
Refer to protocols to this Convention that establish more specific requirements and methods.

TRANSBOUNDARY POLLUTION	
Title: Protocol to the Convention on Long-Range Transboundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes	
Location of Adoption: Sofia	**Year of Adoption:** 1988
Overall Treaty Status: Entered into force in 1991	
Treaty Status in U.S.: Signed in 1988, Ratified in 1989 **U.S. Delegation:** State Department Lead	
Parties that have Signed and Ratified the Treaty: 26 including the U.S.	

Summary of Purpose:
To prevent further increases of emissions of NO_x or their transboundary fluxes and to apply an effects-based approach to address photochemical pollution, acidification and eutrophication, and their effects on human health, the environment and materials, by addressing all significant emission sources.

Methods to Accomplish Purpose:
Requires Parties to stop the increase in emissions of NO_x or their transboundary fluxes by 1994. The general reference year is 1987 (with the exception of the United States, which chose to relate its emission target to 1978). The second step of the NO_x Protocol requires applying an effects-based approach.

Current Status/Relevant Issues:
Taking the sum of emissions of Parties to the NO_x Protocol in 1994, or a previous year, where no recent data are available, a reduction of 9% compared to 1987 can be noted. Nineteen of the Parties have

reached the target and stabilized emissions at 1987 (or in the case of the United States 1978) levels or reduced emissions below that level according to the latest emission data reported.

Refer to the main Convention for active task forces and working groups.

Potential application of NASA Earth science research:
Moderate. The emissions reduction goals for this protocol have been met, so there is limited use for new global scale monitoring. However, further work is being done on effects and geospatial scale of NO_X, so measurements and understanding of NO_2 from new sensors such as OMI may increase interest in this issue, especially how NO_2 emissions relate to nitrate aerosols and acid deposition.

TRANSBOUNDARY POLLUTION	
Title: Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning The Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	
Location of Adoption: Sofia	**Year of Adoption:** 1991
Overall Treaty Status: Entered into force in 1997	
Treaty Status in U.S.: Signed in 1991 but not ratified	

[147] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, http://www.unece.org/env/lrtap/conv/lrtap_o.htm, accessed 7/21/04.

U.S. Delegation: State Department Lead

Parties that have Signed and Ratified the Treaty: 21 (not the U.S.)

Summary of Purpose:
To prevent further increases of emissions of VOCs or their transboundary fluxes

Methods to Accomplish Purpose:
This Protocol specifies three options for emission reduction targets that have to be chosen upon signature or upon ratification:

(i) 30% reduction in emissions of VOCs by 1999 using a year between 1984 and 1990 as a basis. (This option has been chosen by Austria, Belgium, Estonia, Finland, France, Germany, Netherlands, Portugal, Spain, Sweden and the United Kingdom with 1988 as base year, by Denmark with 1985, by Liechtenstein, Switzerland and the United States with 1984, and by Czech Republic, Italy, Luxembourg, Monaco and Slovakia with 1990 as base year);

(ii) The same reduction as for (i) within a Tropospheric Ozone Management Area (TOMA) specified in annex I to the Protocol and ensuring that by 1999 total national emissions do not exceed 1988 levels. (Annex I specifies TOMAs in Norway (base year 1989) and Canada (base year 1988));

(iii) Finally, where emissions in 1988 did not exceed certain specified levels, Parties may opt for a stabilization at that level of emission by 1999. (This has been chosen by Bulgaria, Greece, and Hungary).[148]

Current Status/Relevant Issues:
Protocol entered into force, but United States did not ratify. Reductions reported by participating Parties. Refer to the main Convention for active task forces and working groups.

Potential application of NASA Earth science research:
Low. While NASA could provide some information on general transport trends, monitoring of VOCs using remote sensing is difficult. Additionally, the deadlines for this protocol have passed.

TRANSBOUNDARY POLLUTION & PERSISTENT ORGANIC POLLUTANTS

Title: Protocol to the Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants

Location of Adoption: Aarhus, Denmark | **Year of Adoption:** 1998

Overall Treaty Status: Entered into force 2003

Treaty Status in U.S.: Signed in 1998 but not ratified

U.S. Delegation: State Department Lead

Parties that have Signed and Ratified the Treaty: 20 (not the U.S.)

Summary of Purpose:
To eliminate any discharges, emissions, and losses of designated POPs.

Methods to Accomplish Purpose:
The Protocol focuses on 16 substances that have been singled out according to agreed risk criteria. The substances comprise 11 pesticides, two industrial chemicals, and three by-products/contaminants. The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex, and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, hexaclorobenzene, and polychlorinated biphenyls [PCBs]). Finally, the Protocol

[148] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, Protocol Concerning the Control of Emissions of Volatile Organic Compounds, http://www.unece.org/env/lrtap/vola_h1.htm, accessed 7/22/04.

severely restricts the use of DDT, HCH (including lindane), and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Parties to reduce their emissions of dioxins, furans, polycyclic aromatic hydrocarbons, and hexachlorobenzene below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous, and medical waste, it establishes specific limit values.

Current Status/Relevant Issues:
Refer to the main Convention for active task forces and working groups, including an Expert Group on POPs.

Potential application of NASA Earth science research:
Moderate. Remote sensing cannot at this time monitor specific POPs. However, the Protocol working groups are conducting research to better understand the transport of these pollutants from remaining sources to sensitive areas such as the Arctic. NASA models, combined with ground-based monitoring data, could provide valuable information on the movement of these pollutants useful for future protocols, if not for monitoring this protocol.

TRANSBOUNDARY POLLUTION	
Title: Protocol to the Convention on Long-Range Transboundary Air Pollution on Heavy Metals	
Location of Adoption: Aarhus, Denmark	**Year of Adoption:** 1998
Overall Treaty Status: Entered into force in 2003	
Treaty Status in U.S.: Signed in 1998, Ratified in 2001 **U.S. Delegation:** State Department Lead	
Parties that have Signed and Ratified the Treaty: 21 **(**including the U.S.)	

Summary of Purpose:
To reduce emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport), and waste incineration. The Protocol targets three particularly harmful metals: cadmium, lead, and mercury.

Methods to Accomplish Purpose:
Requires Parties to reduce their emissions for cadmium, lead, and mercury below their levels in 1990 (or an alternative year between 1985 and 1995). The Protocol lays down stringent limit values for emissions from stationary sources and suggests best available techniques for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol. It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides, and paint.

Current Status/Relevant Issues:
Refer to the main Convention for active task forces and working groups, including an Expert Group on Heavy Metals.

Potential application of NASA Earth science research:
Moderate. Remote sensing cannot at this time monitor these metals accurately. However, there is a need to better understand the transport of these pollutants from sources to sensitive areas, such as lakes and other water bodies. NASA models, combined with ground-based monitoring data, could provide information on the movement of these pollutants useful for future protocols, if not for monitoring this protocol.

TRANSBOUNDARY POLLUTION	
Title: Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Protocol to the Convention on Long-Range Transboundary Air Pollution)	
Location of Adoption: Gothenburg	**Year of Adoption:** 1999
Overall Treaty Status: Signed but not in force **Criteria Required for Entry into Force:** 16 signatories need to ratify for the protocol to enter into force.	
Treaty Status in U.S.: Signed in 1999, ratified in November 2004 **U.S. Delegation:** State Department Lead	
Parties that have Signed and Ratified the Treaty: 14	
Summary of Purpose: To abate acidification, eutrophication, and ground-level ozone. **Methods to Accomplish Purpose:** The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_X, VOCs, and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. The Protocol also sets tight limit values for specific emission sources (e.g., combustion plant, electricity production, dry cleaning, cars, and lorries) and requires best available techniques to be used to keep emissions down. VOC emissions from such products as paints or aerosols will also have to be cut. Farmers will have to take specific measures to control ammonia emissions. Guidance documents adopted together with the Protocol provide a wide range of abatement techniques and economic instruments for reducing emissions in the relevant sectors, including transport.[149] **Current Status/Relevant Issues:** Refer to the main Convention for active task forces and working groups.	
Potential application of NASA Earth science research: High. Depends upon whether LRTAP becomes primarily European focused, or is broadened into a hemispheric or global treaty. Several of the precursors to ozone can be measured with remote sensing, and more advanced tropospheric ozone monitoring techniques are expected with the OMI sensor on Aura. NASA sensors and models could provide information about regional sources and transocean transport to support this protocol. With ceilings to go into effect by 2010, the timing for NASA participation is good.	

B2.1.2 Global Transboundary Environmental Impact Assessment

TRANSBOUNDARY POLLUTION	
Title: Convention on Environmental Impact Assessment in a Transboundary Context [150]	
Location of Adoption: Espoo	**Year of Adoption:** 1991
Overall Treaty Status: Entered into force in 1997	

[149] United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, http://www.unece.org/env/lrtap/multi_h1.htm, accessed 7/22/04.

[150] Convention has a Protocol on Strategic Environmental Assessment (Kiev, 2003), focused on official strategic planning and programs. The United States is not a signatory to the Protocol. http://www.unece.org/env/eia/sea_protocol.htm, accessed 7/23/04.

Treaty Status in U.S.: Signed in 1991 but not ratified **U.S. Delegation:** State Department Lead
Parties that have Signed and Ratified the Treaty: 40 (not the U.S.)
Summary of Purpose: To enhance international co-operation in assessing environmental impact particularly in a transboundary context. **Methods to Accomplish Purpose:** The Convention stipulates the obligations of Parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries, and to conduct post-project analysis if requested by any concerned Party. **Current Status/Relevant Issues:** An Implementation Committee was established by the Meeting of the Parties in February 2001. The Committee's objective is to review compliance by the Parties with their obligations under the Convention, with a view to assisting them fully to meet their commitments. The next (sixth) meeting of the Implementation Committee will be held 3-5 November 2004.[151] The Working Group on environmental Impact Assessments (EIA) is a subsidiary body to the Meeting of the Parties, established to assist in implementing the Convention and managing the work plan. The United States has participated in the Working Group. Issues being addressed by the Working Group include public participation in EIAs in a transboundary context and preparation of an EIA database. [152]
Potential application of NASA Earth science research: Moderate. For specific projects, NASA data and models could be used to evaluate impact to air quality and other transboundary environmental impacts. They could also be used in some cases to monitor compliance and results.

B2.2 Agreements With Canada and Mexico

B2.2.1 General

TRANSBOUNDARY POLLUTION	
Title: Agreement on Great Lakes Water Quality	
Location of Adoption: Ottawa, Canada	**Year of Adoption:** 1978, Amendments 1983, 1987
Overall Treaty Status: In force	
Agreement Status in U.S.: In force **U.S. Delegation:** State Department Lead	
Parties that have Signed and Ratified the Treaty: Canada and U.S.	

[151] United Nations Economic Commission for Europe, Convention on Environmental Impact Assessment in a Transboundary Context Implementation Committee, http://www.unece.org/env/eia/implementation.htm, accessed 7/26/04.

[152] Meeting of the Parties to the Convention on Environmental Impact Assessment in a Transboundary Context Working Group on Environmental Impact Assessment, Seventh meeting, Geneva, 28-30 January 2004, http://www.unece.org/env/documents/2004/eia/wg.1/mp.eia.wg.1.2004.1.e.pdf, accessed 7/22/04.

Summary of Purpose:
The Agreement, first signed in 1972 and renewed in 1978, expresses the commitment of each country to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem and includes a number of objectives and guidelines to achieve these goals. A Phosphorus Load Reduction Supplement was added to the Agreement in 1983. Subsequently, a Protocol was signed in 1987 amending the 1978 Agreement. The amendments aim to strengthen the programs, practices, and technology described in the 1978 Agreement and to increase accountability for their implementation. Timetables are set for implementation of specific programs.

Methods to Accomplish Purpose:
The Parties meet biennially to discuss progress and report periodically to the International Joint Commission (IJC). New annexes address atmospheric deposition of toxic pollutants, contaminated sediments, groundwater, and non-point sources of pollution.[153]

Of particular relevance to air quality, in 1966 the governments of Canada and the United States asked the IJC to monitor air quality along the entire Canada-United States boundary and, as appropriate, bring air pollution problems to their attention. The IJC subsequently established the International Air Quality Advisory Board. The role of the Board is to identify and provide advice on air pollution issues with transboundary implications. Pollutants entering the Great Lakes from the air are of particular concern and constitute part of the ecosystem approach espoused in the Great Lakes Water Quality Agreement. The 10 Board members possess expertise in various aspects of air pollution effects and control. Appointed by the IJC, they serve in their personal and professional capacities.

Current Status/Relevant Issues:
Refer to Section 2.2.2 of this appendix for information on the current activities of the International Air Quality Advisory Board in support of this and other international agreements.

Potential application of NASA Earth science research:
Moderate to low. NASA experts may be able to participate on or otherwise support the International Air Quality Advisory Board.

TRANSBOUNDARY POLLUTION	
Title: Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area	
Location of Adoption: La Paz, Mexico	**Year of Adoption:** 1984, Amendments 1983, 1987
Overall Treaty Status: In force	
Agreement Status in U.S.: In force **U.S. Delegation:** EPA and border state governments	
Parties that have Signed and Ratified the Treaty: Mexico and U.S.	

Summary of Purpose:
To protect the environment and public health in the United States—Mexico border region, consistent with the principles of sustainable development. The scope of the agreement and its annexes is limited to the area within 100 miles of each side of the U.S.-Mexico border.

Methods to Accomplish Purpose:
The U.S.-Mexico Border 2012 Program focuses on environmental issues in the United States—Mexico border region. With the active participation of the 10 border states and U.S. tribal governments, the U.S.

[153] International Joint Commission, http://www.ijc.org/rel/agree/quality.html, accessed 7/20/04.

EPA, and Mexico's Secretariat of Environment and Natural Resources, in partnership with the U.S. Department of Health and Human Services, the Mexican Secretariat of Health, and other Federal agencies, the Border 2012 Program focuses on protecting the environment and the public's health in the United States—Mexico border region.

The 10-year Border 2012 Program emphasizes a bottom-up, regional approach, anticipating that local decision-making, priority-setting, and project implementation will best address environmental issues in the border region. It brings together a wide variety of stakeholders to produce prioritized and sustained actions that consider the environmental needs of the different border communities.[154]

One of the ways the Border 2012 Program supports its mission is by collecting, managing, and exchanging environmental data essential to effective environmental management. Some examples include harmonizing binational environmental protocols or information management systems (e.g., hazardous waste tracking systems) and developing effective data collection and information exchange mechanisms between Border 2012 partners and border stakeholders.

Two Annexes are relevant to air quality:

- Annex IV: Agreement of cooperation regarding transboundary air pollution caused by copper smelters along their common border.
- Annex V: Agreement of cooperation regarding international transport of urban air pollution, with appendix.

Current Status/Relevant Issues:
There are a number of active regional and border-wide workgroups, including the Cooperative Enforcement and Compliance border-wide workgroup that identifies and prioritizes border-wide/transboundary issues.[155]

Potential application of NASA Earth science research:
Moderate. NASA is a key participant in the education and observation activities under this Agreement through the GLOBE Program. NASA Earth science could expand its involvement by contributing to the collection of environmental data in support of this agreement, notably transboundary air pollution (Annex V) and land use issues.

TRANSBOUNDARY POLLUTION	
Title: North American Agreement on Environmental Cooperation (NAAEC) (commonly referred to as the NAFTA environmental side agreement)	
Location of Adoption: Mexico; Canada; and Washington, DC	**Year of Adoption:** 1993
Overall Agreement Status: Entered into force in 1994	
Agreement Status in U.S.: In force **U.S. Delegation:** The State Department has responsibility for all questions regarding the interpretation of the agreement. The EPA Administrator is the U.S. representative on the Council of the Commission on Environmental Cooperation (CEC). The U.S. government also appoints five stakeholders from the United States, representing a wide array of interests, to the Joint Public Advisory Committee (JPAC).	

[154] United States—Mexico Environmental Program: Border 2012, http://www.epa.gov/usmexicoborder/intro.htm, accessed 8/9/04.
[155] Ibid.

Parties that have Signed the Agreement: Mexico, Canada and U.S.

Summary of Purpose:
Establishes a general framework for cooperation among the three North American governments on a wide range of environmental affairs.

Methods to Accomplish Purpose:
The NAAEC established the CEC, which coordinates environmental cooperation. The Commission established by the agreement is composed of a Council, a Secretariat, and the JPAC. The Council is the governing body and is composed of representatives of the governments. The three environment ministers represent their governments on the Council. The EPA Administrator is the designated U.S. representative on the Council, and EPA has lead responsibility for managing the interagency process that develops U.S. positions and guides our participation in the CEC. The Department of State works closely with EPA and maintains responsibility on all questions regarding the interpretation of the agreement.[156]

Current Status/Relevant Issues:
The NAAEC is active on a range of issues. For air quality, the Border Air Quality Strategy was designed to reduce local air pollution problems by facilitating the exchange of information, fostering the integration of energy and air quality goals, promoting coordinated planning and management, and encouraging innovation.

Potential application of NASA Earth science research:
Low. NASA may be able to assist in identifying transboundary pollution issues and advising the JPAC and CEC. Other border agreements may be more relevant for direct NASA applications.

B2.2.2 U.S.-Canada Bilateral Air Quality

TRANSBOUNDARY POLLUTION	
Title: U.S.—Canada Bilateral Air Quality Executive Agreement (Including Annexes 1 and 2)	
Location of Adoption: Ottawa, Canada	**Year of Adoption:** 1991
Overall Treaty Status: Entered into force in 1991	
Agreement Status in U.S.: In force **U.S. Delegation:** State Department Lead, EPA, and others.	
Parties that have Signed and Ratified the Treaty: Canada and U.S.	

Summary of Purpose:
The Agreement establishes a formal and flexible method of addressing transboundary air pollution and lays the groundwork for cooperation on a variety of air quality issues.

Methods to Accomplish Purpose:
The Agreement lays out overall air quality objectives and specific requirements for Canada and the United States, including regular communication, exchange of information, and consultation and settlement of issues of concern.

A bilateral Air Quality Committee is responsible for coordinating the overall implementation of the Agreement. Two subcommittees—Program Monitoring and Reporting, and Scientific Cooperation—meet annually with the Air Quality Committee and carry out yearly activities. The two nations prepare a joint progress report every two years and conduct a regular five-year review and assessment of the Agreement.

[156] North American Commission for Environmental Cooperation, www.cec.org/home/index.cfm?varlan=english, accessed 7/28/04.

The Agreement includes two Annexes. Annex 1, the Acid Rain Annex, focuses on the commitments of both nations to reduce SO_2 and NO_x emissions and to monitor utility emissions. Under Annex 2, the Scientific and Technical Activities and Economic Research Annex, Canada and the United States agree to coordinate their air pollution monitoring networks; use compatible formats and methods for monitoring and reporting; and cooperate and exchange information about the causes and effects of air pollution and the use of market-based programs, such as the U.S. Acid Rain Program, to address air pollution issues.

Current Status/Relevant Issues:
Since the Agreement entered into force, work has focused on achieving reductions in emissions of the two major acid rain pollutants: SO_2 and NO_X. Both parties have recorded excellent progress in complying with the SO_2 and NO_X emission reduction goals in the Agreement. The Air Quality Committee established by the Agreement works through the IJC (see Section 2.2.2), which has established the International Air Quality Advisory Board. The role of the Board is to identify and provide advice on air pollution issues with transboundary implications. Information and advice is provided to the IJC by the International Air Quality Advisory Board through semi-annual progress reports, workshops, technical analyses, and published reports on the many aspects of transboundary air pollution.[157] The work of the International Air Quality Advisory Board is a major area of activity with respect to the U.S.—Canada Bilateral Air Quality Executive Agreement and its annexes. The Air Quality Advisory Board has issued many recent publications addressing various issues related to transboundary pollution. [158]

Potential application of NASA Earth science research:
High. NASA sensors and models can be used as part of Annex 1 to monitor sulfate and nitrate transport across boundaries and as part of the monitoring networks coordinated under Annex 2.

TRANSBOUNDARY POLLUTION	
Title: Annex 3, the Ozone Annex, to the U.S.-Canada Bilateral Air Quality Executive Agreement	
Location of Adoption: Ottawa, Canada	**Year of Adoption:** 2000
Overall Treaty Status: Entered into force in 2000	
Treaty Status in U.S.: In force **U.S. Delegation:** State Department Lead, EPA, and others.	
Parties that have Signed and Ratified the Treaty: Canada and U.S.	

Summary of Purpose:
To control transboundary ground-level ozone.

Methods to Accomplish Purpose:
Annex 3, the Ozone Annex, commits the two nations to reducing emissions of NO_x and VOCs. The Ozone Annex establishes a transboundary region, known as the Pollutant Emission Management Area (PEMA), which includes central and southern Ontario, southern Quebec, 18 U.S. states, and the District of Columbia. The provinces and states within the PEMA region are the areas of primary concern for the impact of transboundary ozone.

To support its committed measures in the Ozone Annex, Canada will expand the National Pollutant

[157] Summary of Critical Air Quality Issues in the Transboundary Region Report from the International Air Quality Advisory Board to the International Joint Commission, ISBN 1-894280-43, http://www.ijc.org/php/publications/pdf/ID1539.pdf, accessed 7/23/04.
[158] International Air Quality Advisory Board Publications, http://www.ijc.org/conseil_board/air_quality_board/iaqab_pub.php?language=english, accessed 7/23/04.

Release Inventory to include annual public reporting of ground-level ozone precursors and components of smog. Other domestic measures in Canada include the Sulphur in Diesel Fuel Regulations and the On-Road Vehicle and Engine Emission Regulations. In addition, the Canadian provinces of Quebec and Ontario have made progress in meeting their commitments under the Ozone Annex.

To further protect against adverse health effects, the U.S. revised the National Ambient Air Quality Standards for ozone in 1997 and recently designated new nonattainment areas for ozone. The United States. is also continuing to implement regulations under the ozone transport reduction rule (known as the NO_x State Implementation Plan Call), which focus on the regional transport of ground-level ozone.

Current Status/Relevant Issues:
Refer to the U.S.—Canada Bilateral Air Quality Executive Agreement summary for ongoing activities.

Potential application of NASA Earth science research:
Moderate to High. Work under Annex 1 and Annex 2 would support this effort. With the launch of Aura and as techniques for monitoring tropospheric ozone develop, support for Annex 3 would increase.

B3.0 STRATOSPHERIC OZONE DEPLETION

STRATOSPHERIC OZONE DEPLETION	
Title: Convention for the Protection of the Ozone Layer	
Location of Adoption: Vienna, Austria	**Year of Adoption:** 1985
Overall Treaty Status: Entered into force in 1988	
Treaty Status in U.S.: Signed in 1985, Ratified in 1986 **U.S. Delegation:** The State Department is the lead agency responsible for coordinating U.S. participation in the Protocol. The EPA is the principal entity responsible for domestic implementation of the Protocol.	
Parties that have Signed and Ratified the Treaty: 172 including the U.S.	
Summary of Purpose: To reduce activities that could threaten the ozone layer. **Methods to Accomplish Purpose:** Calls upon parties to take measures against activities that could threaten the ozone layer but does not contain any explicit controls on chlorofluorocarbons (CFCs). **Current Status/Relevant Issues:** Refer to the 1992 Copenhagen Protocol to this Convention.	
Potential application of NASA Earth science research: Refer to protocols to this Convention that established more specific requirements and methods.	

STRATOSPHERIC OZONE DEPLETION	
Title: Montreal Protocol on Substances that Deplete the Ozone Layer	
Location of Adoption: Montreal	**Year of Adoption:** 1987
Overall Treaty Status: Entered into force in 1989	
Treaty Status in U.S.: Signed in 1987, ratified in 1988 **U.S. Delegation:** The State Department is the lead agency responsible for coordinating U.S. participation in the Protocol. The EPA is the principal entity responsible for domestic implementation of the Protocol.	
Parties that have Signed and Ratified the Treaty: 171 including the U.S.	
Summary of Purpose: To reduce activities that could threaten the ozone layer. **Methods to Accomplish Purpose:** Requires a 50% reduction in the production and use of CFCs by the year ending June 30, 1998, as well as restrictions on halons. The Protocol also includes provisions to establish a Multilateral Fund to provide financial and technical assistance to developing country Parties to assist them in meeting their obligations under the Protocol. As the largest contributor to the Multilateral Fund, the United States has made available over $340 million to the Fund since its inception.[159] **Current Status/Relevant Issues:** Refer to the 1992 Copenhagen Protocol to this Convention.	
Potential application of NASA Earth science research: Low. Beyond current monitoring of the ozone layer, new technology would need to be developed to specifically detect CFCs or other ozone-depleting substances.	

[159] U.S. Department of State, Implementation of Environmental Treaties, http://www.state.gov/g/oes/rls/rm/2002/12157.htm, accessed 7/20/04.

STRATOSPHERIC OZONE DEPLETION	
Title: Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	
Location of Adoption: London	**Year of Adoption:** 1990
Overall Treaty Status: Entered into force in 1992	
Treaty Status in U.S.: Signed in 1990, Ratified in 1991 **U.S. Delegation:** The State Department is the lead agency responsible for coordinating U.S. participation in the Protocol. The EPA is the principal entity responsible for domestic implementation of the Protocol.	
Parties that have Signed and Ratified the Treaty: 131 including the U.S.	
Summary of Purpose: To reduce activities that could threaten the ozone layer. **Methods to Accomplish Purpose:** Requires the total phase-out of CFCs, most halons, and carbon tetrachloride by 2000. Also requires that production of two other ozone-depleting chemicals, methylchloroform and hydrochlorofluorocarbons (HCFCs), cease by 2010 and 2040, respectively. **Current Status/Relevant Issues:** Refer to the 1992 Copenhagen Protocol to this Convention.	
Potential application of NASA Earth science research: Low. Beyond current monitoring of the ozone layer, new technology would need to be developed to specifically detect CFCs or other ozone-depleting substances.	

STRATOSPHERIC OZONE DEPLETION	
Title: Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	
Location of Adoption: Copenhagen	**Year of Adoption:** 1992
Overall Treaty Status: Entered into force in 1994	
Treaty Status in U.S.: Signed in 1992, Ratified in 1994 **U.S. Delegation:** The State Department is the lead agency responsible for coordinating U.S. participation in the Protocol. The EPA is the principal entity responsible for domestic implementation of the Protocol.	
Parties that have Signed and Ratified the Treaty: 131 including the U.S.	
Summary of Purpose: To reduce activities that could threaten the ozone layer. **Methods to Accomplish Purpose:** Requires the total phase-out of halons on January 1, 1994, and that of most other controlled substances by January 1, 1996 (except for HCFCs, for which the date was moved up to 2030). **Current Status/Relevant Issues:** Two additional amendments to the Montreal Protocol (1997 in Montreal, and 1999 in Beijing) were adopted. Both of these amendments focused on trade activities. The First Extraordinary Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer was held in March 2004 to specifically address methyl bromide. Representatives of the United States attended this meeting. One conclusion was that a better understanding of the scientific issues is needed in the context of a methyl bromide phase-out.[160]	

[160] United Nations Environment Programme, First Extraordinary Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer Montreal, 24–26 March, 2004, http://www.unep.org/ozone/Meeting_Documents/mop/Ex_mop/1ex_mop-3.e.doc, accessed 7/21/04.

Potential application of NASA Earth science research:
Low. Beyond current monitoring of the ozone layer, new technology would need to be developed to specifically detect CFCs or other ozone-depleting substances.

B4.0 PERSISTENT ORGANIC POLLUTANTS

PERSISTENT ORGANIC POLLUTANTS	
Title: Stockholm Convention on Persistent Organic Pollutants	
Location of Adoption: Stockholm	**Year of Adoption:**2001
Overall Treaty Status: Entered into force in 2004	
Treaty Status in U.S.: Signed in 2001 but not ratified **U.S. Delegation:** State Department and EPA	
Parties to the Treaty (nations that have signed and ratified the treaty): 72 (not the U.S.)	

Summary of Purpose:
The Stockholm Convention is a global treaty to protect human health and the environment from POPs. The 12 POPs chemicals (known as the "dirty dozen") covered by the POPs Convention are aldrin, hexachlorobenzene, chlordane, mirex, DDT, toxaphene, dieldrin, PCBs, endrin, polychlorinated dibenzo-p-dioxins (dioxins), heptachlor, and polychlorinated dibenzo furans (furans).The 12 POPs have four intrinsic characteristics: toxic and known to have deleterious health or environmental impacts; have the potential to bioaccumulate through the food chain and become more concentrated as they move from one creature to another; stable and resistant to natural breakdown; and can be transported over long distances.[161, 162]

Methods to Accomplish Purpose:
Requires Parties to take measures to eliminate or reduce the release of POPs into the environment. Each Party is required to develop and endeavor to implement a plan to meet its obligations under the Convention. The Convention includes a flexible system of financial and technical assistance by which developed countries will help developing countries meet their obligations. The Global Environment Facility has already initiated action to provide financial assistance to developing countries to help them implement the Convention. All 12 of these chemicals are already banned or tightly controlled in the United States.

The POPs Convention creates a science-based procedure that will govern the inclusion of additional chemicals to the Convention. In accordance with Article 8, paragraph 7(a) of the Convention, this science-based procedure will involve an evaluation of whether "the chemical is likely as a result of its long-range environmental transport to lead to significant adverse human health and/or environmental effects such that global action is warranted . . ."

UNEP Chemicals has initiated a global network for monitoring chemicals in the environment, focusing initially on POPs. A workshop to develop a POPs Global Monitoring Program was held in March 2003 in Geneva.[163]

Current Status/Relevant Issues:
Implementation and monitoring activities on-going. The First Meeting of the Conference of the Parties of the Stockholm Convention is scheduled for May 2005.

[161] U.S. Department of State, Hearing on International Treaty Agreements (POPS, PIC, Albacore Tuna, South Pacific Tuna Access, and Polar Bear), John F. Turner, Assistant Secretary; Bureau of Oceans and International, Environmental and Scientific Affairs Testimony before the Senate Foreign Relations Committee, Washington, DC, June 17, 2003, http://www.state.gov/g/oes/rls/rm/2003/21664.htm, accessed 7/23/04.
[162] U.S. Environmental Protection Agency, Persistent Organic Pollutants, http://www.epa.gov/oppfead1/international/pops.htm.
[163] United Nations Environment Programme, Chemicals Master List of Actions on the Reduction and/or Elimination of the Releases of Persistent Organic Pollutants, http://www.pops.int/documents/meetings/inc7/mastlist5/ml5.pdf, accessed 7/24/04.

Potential application of NASA Earth science research:
Moderate. Current NASA remote sensing cannot monitor specific POPs. NASA models, combined with ground-based monitoring data, could provide valuable information on the movement of these pollutants useful for monitoring this Convention.

B5.0 LAND USE

DESERTIFICATION	
Title: Convention to Combat Desertification, Particularly in Africa (CCD)	
Location of Adoption: Paris, France	**Year of Adoption:**1994
Overall Treaty Status: Entered into force in 1996	
Treaty Status in U.S.: Signed in 1994, Ratified in 2000 **U.S. Delegation:** The U.S. Agency for International Development (USAID) is the lead U. S. Government agency implementing the CCD overseas. The Department of the Interior (Bureau of Land Management) and the Department of Agriculture also carry out program activities in support of the implementation of the Convention.	
Parties to the Treaty (nations that have ratified the treaty): 191 including the U.S.	
Summary of Purpose: To combat desertification and ensure the long-term productivity of inhabited drylands (e.g., parts of Africa; the American west; the Aral Sea in Russia; Argentina; and islands of the Caribbean, Indonesia, and the Mediterranean). The United States. is a party to this Convention since approximately 40% of the U.S. landmass is considered arid, semi-arid, or dry sub-humid, and therefore susceptible to the processes of desertification. **Methods to Accomplish Purpose:** Countries affected by desertification are implementing the Convention by developing and carrying out national, sub-regional, and regional action programs. Criteria for preparing these programs are detailed in the treaty's five "regional implementation annexes": Africa (considered a priority because that is where desertification is most severe), Asia, Latin America and the Caribbean, the Northern Mediterranean, and Central and Eastern Europe. Drawing on past lessons, the Convention states that these programs must adopt a democratic, bottom-up approach. They should emphasize popular participation and the creation of an "enabling environment" designed to allow local people to help themselves to reverse land degradation. The Convention's action programs are being developed through consultation among affected countries, donors, and intergovernmental and non-governmental organizations. This process will improve coordination and channel development assistance to where it can be most effective. It will also produce partnership agreements that spell out the respective contributions of both affected and donor States and of international organizations. Developed countries are expected to encourage the mobilization of substantial funding for the action programs and promote access to appropriate technologies and knowledge. Bilaterally and regionally, the United States works with affected developing country Parties, local and international non-governmental organizations, and multilateral development banks on anti-desertification program activities, including education, community development, and capacity building, with the goal of empowering local people to combat desertification by identifying needs and solving problems themselves. **Current Status/Relevant Issues:** The UN released a report on June 10, 2004, marking the 10th anniversary of the Convention.[164] The report noted that the identification of desertification indicators, the promotion of the establishment of desertification monitoring and evaluation systems, and the prevention of famine by means of early warning systems are all activities for which the Convention stimulated exchange and the dissemination of	

[164] United Nations, "Preserving our common ground: UNCCD Ten years on, http://www.unccd.int/publicinfo/publications/UNCCD_magazine-eng.pdf, accessed 8/5/04.

vital information in the regions most concerned.

The Committee on Science and Technology (CST) was established as a subsidiary body of the Conference of the Parties (COP) to provide it with information and advice on scientific and technological matters relating to combating desertification and mitigating the effects of drought. The CST is composed of government representatives competent in the fields of expertise relevant to combating desertification and mitigating the effects of drought. It is multi-disciplinary and open to the participation of all Parties. It meets in conjunction with the ordinary sessions of the COP. The last Meeting of the Bureau of the Sixth Session of the Conference of the Parties was held in Germany on June 6, 2004.

TESEO has conducted a pilot project regarding the use of Earth observations to support this agreement.

Potential application of NASA Earth science research:
High. NASA can play a role in monitoring the changes in land use in sensitive regions, as well as the transport of dust resulting from an increase in desertification. NASA could also play a strong role in disseminating technology and scientific and technical information, promoting access to appropriate monitoring technologies, and training scientists and decision makers in other countries in utilizing land use and air pollutant monitoring technologies. NASA could also benchmark the TESEO pilot project and experience of the European Space Agency.

B6.0 OTHER

GENERAL AIR POLLUTION	
Title: International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)[165]	
Location of Adoption: London	**Year of Adoption:**1978
Overall Treaty Status: Annexes 1 and 2 of the Convention entered into force in 1983, see Methods to Accomplish Purpose below for other Annexes	
Treaty Status in U.S.: In force **U.S. Delegation:** State Department lead, EPA and others.	
Parties to the Treaty (nations that have signed and ratified the treaty): 127 (Annexes 1 and 2) including U.S.	
Summary of Purpose: The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 and updated by amendments through the years.	
Methods to Accomplish Purpose: The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental and from routine operations, and currently includes six technical Annexes. Annex VI, Prevention of Air Pollution from Ships, was adopted in September 1997, set to enter into force on May 19, 2005, following the ratification by the Independent State of Samoa. Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and CFCs. Annex VI also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and PCBs. The regulations in this annex, when they come into force, will set limits on SO_x and NO_x emissions from ship exhausts and prohibit deliberate emissions of ozone-depleting substances. The regulations include a global cap of 4.5% on the sulphur content of fuel oil and contain provisions allowing for special "SO_X Emission Control Areas" to be established with more stringent controls on sulphur emissions.[166]	
Current Status/Relevant Issues: The Convention is being implemented in phases with the air pollution annex coming into force in 2005.	
Potential application of NASA Earth science research: Moderate to High. For air quality, there may be some application in monitoring ship plumes, but current spatial and temporal resolutions and the range of chemical species that can be monitored will significantly limit this application. Interesting potential application to research on monitoring general air pollution in shipping. For non-air quality Annexes, one example of ongoing application of Earth observation systems and associated data and information is oil pollution monitoring of the seas using synthetic aperture radar to support this Convention.[167]	

[165] International Maritime Organization (IMO), Status of Multilateral Conventions and Instruments in Respect of while the International Maritime Organization or its Secretary-General Performs Depository or other Functions, 31 December 2002, http://www.imo.org/includes/blastDataOnly.asp/data_id%3D8140/8387.pdf, accessed 8/23/04.
[166] IMO, http://www.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258, accessed 8/9/04.
[167] American Institute of Aeronautics and Astronautics, International Activities Committee, 6th International Space Cooperating Workshop Report, March 2001, http://sedac.ciesin.columbia.edu/rs-treaties/AIAA6thWorkshop.pdf, accessed 7/20/04.

GENERAL AIR POLLUTION	
Title: World Health Organization (WHO) Air Quality Guidelines	
Location of Adoption: Not applicable	**Year of Adoption:** Published in 1987, Revised in 2000
Overall Treaty Status: Not applicable	
Treaty Status in U.S.: Not applicable **U.S. Delegation:** Not applicable	
Parties to the Treaty (nations that have signed and ratified the treaty): Not applicable	
Summary of Purpose: The WHO Air Quality Guidelines for Europe, and revised version completed in 2000, have provided a uniform basis for developing strategies to control of air pollution and have contributed to the maintenance and improvement of public health in several countries. The Guidelines aim to provide a basis to protect public health from the adverse effects of air pollutants and to eliminate or reduce to a minimum those pollutants that are known or are likely to be hazardous to human health and wellbeing. In providing pollutant levels below which lifetime exposure or exposure for a given averaging time does not constitute a health risk, they form a basis for setting national standards for air pollution. **Methods to Accomplish Purpose:** The primary aim of these Guidelines is to provide a uniform basis for protecting public health and ecosystems from the adverse effects of air pollution and to eliminate or reduce to a minimum exposure to those pollutants that are known or are likely to be hazardous. The Guidelines are based on the scientific knowledge available at the time of their development. They have the character of recommendations, and it is not intended or recommended that they simply be adopted as standards. Nevertheless, countries may wish to transform the recommended Guidelines into legally enforceable standards.[168] **Current Status/Relevant Issues:** A variety of laws and programs aimed at addressing urban air quality are administered by individual cities and nations, development banks, global organizations, and U.S. government agencies such as the EPA and the USAID.	
Potential application of NASA Earth science research: Moderate. Data from sensors such as MODIS have been correlated with ground-based air pollutants such as particulate matter and sulfate. Satellites can provide information about air pollutants in regions with few or no monitors, assisting WHO in both improving its estimates of the human health impacts of air pollution and prioritizing action.	

[168] World Health Organization Air Quality Guidelines, http://www.euro.who.int/air/Activities/20020620_1, accessed 7/23/04.